RECENT ADVANCES in ENVIRONMENTAL SCIENCE and GEOSCIENCE

Proceedings of the 2014 International Conference on Environmental Science and Geoscience (ESG '14)

Venice, Italy
March 15-17, 2014

RECENT ADVANCES in ENVIRONMENTAL SCIENCE and GEOSCIENCE

Proceedings of the 2014 International Conference on Environmental Science and Geoscience (ESG '14)

Venice, Italy
March 15-17, 2014

All papers of the present volume were peer reviewed by no less than two independent reviewers. Acceptance was granted when both reviewers' recommendations were positive.

Series: Energy, Environmental and Structural Engineering Series - 23

ISSN: 2227-4359
ISBN: 978-1-61804-224-8

RECENT ADVANCES in ENVIRONMENTAL SCIENCE and GEOSCIENCE

Proceedings of the 2014 International Conference on Environmental Science and Geoscience (ESG '14)

Venice, Italy
March 15-17, 2014

Organizing Committee

General Chairs (EDITORS)

- Prof. Vladimir Sokolov,
  University of Karlsruhe,
  Karlsruhe, Germany
- Prof. Rui Pedro Juliao,
  Universidade Nova De Lisboa
  Lisbon, Portugal
- Prof. Aida Bulucea,
  University of Craiova, Romania

Senior Program Chair

- Prof. Shoji Arai, Kanazawa University,
  Kanazawa, Ishikawa Prefecture,
  Japan

Program Chairs

- Prof. Filippo Neri
  Dipartimento di Informatica e Sistemistica
  University of Naples "Federico II"
  Naples, Italy
- Prof. Constantin Udriste,
  University Politehnica of Bucharest,
  Bucharest, Romania
- Prof. Sandra Sendra
  Instituto de Inv. para la Gestión Integrada de Zonas Costeras (IGIC)
  Universidad Politécnica de Valencia
  Spain

Tutorials Chair

- Professor Pradip Majumdar
  Department of Mechanical Engineering
  Northern Illinois University
  Dekalb, Illinois, USA

Special Session Chair

- Prof. Hing-Ho Tsang,
  Swinburne University of Technology,
  Melbourne, Australia

Workshops Chair

- Prof. Ryszard S. Choras
  Institute of Telecommunications
  University of Technology & Life Sciences
  Bydgoszcz, Poland

Local Organizing Chair

- Assistant Prof. Klimis Ntalianis,
  Tech. Educ. Inst. of Athens (TEI),
  Athens, Greece

Publication Chair

- Prof. Gen Qi Xu
  Department of Mathematics
  Tianjin University
  Tianjin, China

Publicity Committee

- Prof. Reinhard Neck
  Department of Economics
  Klagenfurt University
  Klagenfurt, Austria
- Prof. Myriam Lazard
  Institut Superieur d' Ingenierie de la Conception
  Saint Die, France

International Liaisons

- Prof. Ka-Lok Ng
  Department of Bioinformatics
  Asia University
  Taichung, Taiwan
- Prof. Olga Martin
  Applied Sciences Faculty
  Politehnica University of Bucharest
  Romania
- Prof. Vincenzo Niola
  Departement of Mechanical Engineering for Energetics
  University of Naples "Federico II"
  Naples, Italy
- Prof. Eduardo Mario Dias
  Electrical Energy and Automation
  Engineering Department
  Escola Politecnica da Universidade de Sao Paulo
  Brazil

Steering Committee

- Professor Aida Bulucea, University of Craiova, Romania
- Professor Zoran Bojkovic, Univ. of Belgrade, Serbia
- Prof. Metin Demiralp, Istanbul Technical University, Turkey
- Professor Imre Rudas, Obuda University, Budapest, Hungary

Program Committee for ENVIRONMENTAL SCIENCE

Prof. Bharat Doshi, John Hopkins University, Mayrland, USA
Prof. Gang Yao, University of Illinois at Urbana - Champaign, USA
Prof. Lu Peng, Luisian State University, Baton Rouge, LA, USA
Prof. Y. Baudoin, Royal Military Academy, Brussels, Belgium
Prof. F. Rigas, School of Chemical Engineering, National Technical University of Athens, Greece.
Prof. S. Sohrab, Northwestern University, IL, USA
Prof. A. Stamou, National Technical University of Athens, Greece
Prof. A. I. Zouboulis, Dept. of Chemistry, Aristotle University of Thessaloniki, Greece
Prof. Z. A. Vale, Instituto Superior de Engenharia do Porto Rua Antonio Bernardino de Almeida, Portugal
Prof. M. Heiermann, Dr., Department of Technology Assessment and Substance Flow, Potsdam, Germany
Prof. I. Kazachkov, National Technical University of Ukraine (NTUU KPI), Kyiv, Ukraine
Prof. A. M.A. Kazim, UAE University, United Arab Emirates
Prof. A. Kurbatskiy, Novosibirsk State University, Department of Physics, Russia
Prof. S. Linderoth, Riso National Laboratory. Denmark
Prof. P. Lunghi, Dipartimento di Ingegneria Industriale, University degli Studi di Perugia, Italy
Prof. Pavel Loskot, Swansea University, UK
Prof. N. Afgan, UNESCO Chair Holder, Instituto Superior Tecnico, Lisbon, Portugal
Prof. F. Akgun, Gebze Kocaeli, Turkey
Prof. Fernando Alvarez, Prof. of Economics, University of Chicago, USA
Prof. Mark J. Perry, Prof. of Finance and Business Economics, University of Michigan-Flit, USA
Prof. Biswa Nath Datta, IEEE Fellow, Distinguished Research Prof., Northern Illinois University, USA
Prof. Panos Pardalos, Center for Applied Optimization, University of Florida, USA
Prof. Gamal Elnagar, University of South Carolina Upstate,Spartanburg, SC, USA
Prof. Luis Tavares Rua, Cmte Guyubricht, 119. Conj. Jardim Costa do Sol. Atalaia, Brazil
Prof. Igor Kuzle, Faculty of electrical engineering and computing, Zagreb, Croatia
Prof. Maria do Rosario Alves Calado, University of Beira Interior, Portugal
Prof. Gheorghe-Daniel Andreescu, "Politehnica" University of Timisoara, Romania
Prof. Jiri Strouhal, University of Economics Prague, Czech Republic
Prof. Morris Adelman, Prof. of Economics, Emeritus, MIT, USA
Prof. Jiri Klima, Technical faculty of CZU in Prague, Czech Republic
Prof. Goricanec Darko, University of Maribor, Maribor, Slovenia
Prof. Ze Santos, Rua A, 119. Conj. Jardim Costa do Sol, Brazil
Prof. Ehab Bayoumi, Chalmers University of Technology,Goteborg, Sweden
Prof. Robert L. Bishop, Prof. of Economics, Emeritus, MIT, USA
Prof. Glenn Loury, Prof. of Economics, Brown University, USA
Prof. Patricia Jota, Av. Amazonas 7675, BH, MG, Brazil
Prof. S. Ozdogan, Marmara University, Goztepe Campus, Kuyubasi, Kadikoy, Istanbul, Turkey

Program Committee for GEOSCIENCE

Prof. Prof. Jian Wang, Los Alamos National Laboratory, Los Alamos, NM, USA
Prof. Bruno Capaccioni, Universita di Bologna, Bologna, Italy
Prof. Levent Yilmaz, Istanbul technical University, Turkey
Prof. Ernst D. Schmitter, University of Applied Sciences Osnabrueck, Germany
Prof. Corina Carranca, University of Algarve, Portugal
Prof. Hing-Ho Tsang, Swinburne University of Technology, Melbourne, Australia
Prof. Paolo Budetta, University of Naples Federico II, Naples, Italy
Prof. Rui Pedro Juliao, Universidade Nova De Lisboa, Lisboa, Portugal
Prof. Victor M. Castano, Universidad Nacional Autonoma de Mexico, Mexioc City, Mexico
Prof. S. V. Dinesh, Siddaganga Institute of Institute of Technology, Tumkur, India
Prof. C. C. Sorrell, University of New South Wales, Sydney, Australia
Prof. Efthimios Karymbalis, Harokopio University, Athens, Greece
Prof. Belkheir Hammouti, Mohammed Premier University, Oujda, Morocco
Prof. Ismail Rakip Karas, Karabuk University, Turkey

Additional Reviewers

Angel F. Tenorio	Universidad Pablo de Olavide, Spain
Ole Christian Boe	Norwegian Military Academy, Norway
Abelha Antonio	Universidade do Minho, Portugal
Xiang Bai	Huazhong University of Science and Technology, China
Genqi Xu	Tianjin University, China
Moran Wang	Tsinghua University, China
Minhui Yan	Shanghai Maritime University, China
Jon Burley	Michigan State University, MI, USA
Shinji Osada	Gifu University School of Medicine, Japan
Bazil Taha Ahmed	Universidad Autonoma de Madrid, Spain
Konstantin Volkov	Kingston University London, UK
Tetsuya Shimamura	Saitama University, Japan
George Barreto	Pontificia Universidad Javeriana, Colombia
Tetsuya Yoshida	Hokkaido University, Japan
Deolinda Rasteiro	Coimbra Institute of Engineering, Portugal
Matthias Buyle	Artesis Hogeschool Antwerpen, Belgium
Dmitrijs Serdjuks	Riga Technical University, Latvia
Kei Eguchi	Fukuoka Institute of Technology, Japan
Imre Rudas	Obuda University, Budapest, Hungary
Francesco Rotondo	Polytechnic of Bari University, Italy
Valeri Mladenov	Technical University of Sofia, Bulgaria
Andrey Dmitriev	Russian Academy of Sciences, Russia
James Vance	The University of Virginia's College at Wise, VA, USA
Masaji Tanaka	Okayama University of Science, Japan
Sorinel Oprisan	College of Charleston, CA, USA
Hessam Ghasemnejad	Kingston University London, UK
Santoso Wibowo	CQ University, Australia
M. Javed Khan	Tuskegee University, AL, USA
Manoj K. Jha	Morgan State University in Baltimore, USA
Miguel Carriegos	Universidad de Leon, Spain
Philippe Dondon	Institut polytechnique de Bordeaux, France
Kazuhiko Natori	Toho University, Japan
Jose Flores	The University of South Dakota, SD, USA
Takuya Yamano	Kanagawa University, Japan
Frederic Kuznik	National Institute of Applied Sciences, Lyon, France
Lesley Farmer	California State University Long Beach, CA, USA
João Bastos	Instituto Superior de Engenharia do Porto, Portugal
Zhong-Jie Han	Tianjin University, China
Francesco Zirilli	Sapienza Universita di Roma, Italy
Yamagishi Hiromitsu	Ehime University, Japan
Eleazar Jimenez Serrano	Kyushu University, Japan
Alejandro Fuentes-Penna	Universidad Autónoma del Estado de Hidalgo, Mexico
José Carlos Metrôlho	Instituto Politecnico de Castelo Branco, Portugal
Stavros Ponis	National Technical University of Athens, Greece

Table of Contents

ISBN: 978-1-61804-224-8

ISBN: 978-1-61804-224-8

Keynote Lecture 1

On the Distinguished Role of the Mittag-Leffler and Wright Functions in Fractional Calculus

Professor Francesco Mainardi
Department of Physics, University of Bologna, and INFN
Via Irnerio 46, I-40126 Bologna, Italy
E-mail: francesco.mainardi@bo.infn.it.it

Abstract: Fractional calculus, in allowing integrals and derivatives of any positive real order (the term "fractional" is kept only for historical reasons), can be considered a branch of mathematical analysis which deals with integro-di erential equations where the integrals are of convolution type and exhibit (weakly singular) kernels of power-law type. As a matter of fact fractional calculus can be considered a laboratory for special functions and integral transforms. Indeed many problems dealt with fractional calculus can be solved by using Laplace and Fourier transforms and lead to analytical solutions expressed in terms of transcendental functions of Mittag-Leffler and Wright type. In this plenary lecture we discuss some interesting problems in order to single out the role of these functions. The problems include anomalous relaxation and diffusion and also intermediate phenomena.

Brief Biography of the Speaker: For a full biography, list of references on author's papers and books see:
Home Page: http://www.fracalmo.org/mainardi/index.htm
and http://scholar.google.com/citations?user=UYxWyEEAAAAJ&hl=en&oi=ao

ISBN: 978-1-61804-224-8

Keynote Lecture 2

Latest Advances in Neuroinformatics and Fuzzy Systems

Yingxu Wang, PhD, Prof., PEng, FWIF, FICIC, SMIEEE, SMACM
President, International Institute of Cognitive Informatics and Cognitive Computing (ICIC)
Director, Laboratory for Cognitive Informatics and Cognitive Computing
Dept. of Electrical and Computer Engineering
Schulich School of Engineering
University of Calgary
2500 University Drive NW,
Calgary, Alberta, Canada T2N 1N4
E-mail: yingxu@ucalgary.ca

Abstract: Investigations into the neurophysiological foundations of neural networks in neuroinformatics [Wang, 2013] have led to a set of rigorous mathematical models of neurons and neural networks in the brain using contemporary denotational mathematics [Wang, 2008, 2012]. A theory of neuroinformatics is recently developed for explaining the roles of neurons in internal information representation, transmission, and manipulation [Wang & Fariello, 2012]. The formal neural models reveal the differences of structures and functions of the association, sensory and motor neurons. The pulse frequency modulation (PFM) theory of neural networks [Wang & Fariello, 2012] is established for rigorously analyzing the neurosignal systems in complex neural networks. It is noteworthy that the Hopfield model of artificial neural networks [Hopfield, 1982] is merely a prototype closer to the sensory neurons, though the majority of human neurons are association neurons that function significantly different as the sensory neurons. It is found that neural networks can be formally modeled and manipulated by the neural circuit theory [Wang, 2013]. Based on it, the basic structures of neural networks such as the serial, convergence, divergence, parallel, feedback circuits can be rigorously analyzed. Complex neural clusters for memory and internal knowledge representation can be deduced by compositions of the basic structures.

Fuzzy inferences and fuzzy semantics for human and machine reasoning in fuzzy systems [Zadeh, 1965, 2008], cognitive computers [Wang, 2009, 2012], and cognitive robots [Wang, 2010] are a frontier of cognitive informatics and computational intelligence. Fuzzy inference is rigorously modeled in inference algebra [Wang, 2011], which recognizes that humans and fuzzy cognitive systems are not reasoning on the basis of probability of causations rather than formal algebraic rules. Therefore, a set of fundamental fuzzy operators, such as those of fuzzy causality as well as fuzzy deductive, inductive, abductive, and analogy rules, is formally elicited. Fuzzy semantics is quantitatively modeled in semantic algebra [Wang, 2013], which formalizes the qualitative semantics of natural languages in the categories of nouns, verbs, and modifiers (adjectives and adverbs). Fuzzy semantics formalizes nouns by concept algebra [Wang, 2010],

verbs by behavioral process algebra [Wang, 2002, 2007], and modifiers by fuzzy semantic algebra [Wang, 2013]. A wide range of applications of fuzzy inference, fuzzy semantics, neuroinformatics, and denotational mathematics have been implemented in cognitive computing, computational intelligence, fuzzy systems, cognitive robotics, neural networks, neurocomputing, cognitive learning systems, and artificial intelligence.

Brief Biography of the Speaker: Yingxu Wang is professor of cognitive informatics and denotational mathematics, President of International Institute of Cognitive Informatics and Cognitive Computing (ICIC, http://www.ucalgary.ca/icic/) at the University of Calgary. He is a Fellow of ICIC, a Fellow of WIF (UK), a P.Eng of Canada, and a Senior Member of IEEE and ACM. He received a PhD in software engineering from the Nottingham Trent University, UK, and a BSc in Electrical Engineering from Shanghai Tiedao University. He was a visiting professor on sabbatical leaves at Oxford University (1995), Stanford University (2008), University of California, Berkeley (2008), and MIT (2012), respectively. He is the founder and steering committee chair of the annual IEEE International Conference on Cognitive Informatics and Cognitive Computing (ICCI*CC) since 2002. He is founding Editor-in-Chief of International Journal of Cognitive Informatics and Natural Intelligence (IJCINI), founding Editor-in-Chief of International Journal of Software Science and Computational Intelligence (IJSSCI), Associate Editor of IEEE Trans. on SMC (Systems), and Editor-in-Chief of Journal of Advanced Mathematics and Applications (JAMA). Dr. Wang is the initiator of a few cutting-edge research fields or subject areas such as denotational mathematics, cognitive informatics, abstract intelligence (□I), cognitive computing, software science, and basic studies in cognitive linguistics. He has published over 160 peer reviewed journal papers, 230+ peer reviewed conference papers, and 25 books in denotational mathematics, cognitive informatics, cognitive computing, software science, and computational intelligence. He is the recipient of dozens international awards on academic leadership, outstanding contributions, best papers, and teaching in the last three decades.

http://www.ucalgary.ca/icic/

http://scholar.google.ca/citations?user=gRVQjskAAAAJ&hl=en

Editor-in-Chief, International Journal of Cognitive Informatics and Natural Intelligence
Editor-in-Chief, International Journal of Software Science and Computational Intelligence
Associate Editor, IEEE Transactions on System, Man, and Cybernetics - Systems
Editor-in-Chief, Journal of Advanced Mathematics and Applications
Chair, The Steering Committee of IEEE ICCI*CC Conference Series

Keynote Lecture 3

Recent Advances and Future Trends on Atomic Engineering of III-V Semiconductor for Quantum Devices from Deep UV (200nm) up to THZ (300 microns)

Professor Manijeh Razeghi
Center for Quantum Devices
Department of Electrical Engineering and Computer Science
Northwestern University
Evanston, Illinois 60208
USA
E-mail: razeghi@eecs.northwestern.edu

Abstract: Nature offers us different kinds of atoms, but it takes human intelligence to put them together in an elegant way in order to realize functional structures not found in nature. The so-called III-V semiconductors are made of atoms from columns III (B, Al, Ga, In. Tl) and columns V(N, As, P, Sb,Bi) of the periodic table, and constitute a particularly rich variety of compounds with many useful optical and electronic properties. Guided by highly accurate simulations of the electronic structure, modern semiconductor optoelectronic devices are literally made atom by atom using advanced growth technology such as Molecular Beam Epitaxy (MBE) and Metal Organic Chemical Vapor Deposition (MOCVD). Recent breakthroughs have brought quantum engineering to an unprecedented level, creating light detectors and emitters over an extremely wide spectral range from 0.2 mm to 300 mm. Nitrogen serves as the best column V element for the short wavelength side of the electromagnetic spectrum, where we have demonstrated III-nitride light emitting diodes and photo detectors in the deep ultraviolet to visible wavelengths. In the infrared, III-V compounds using phosphorus ,arsenic and antimony from column V ,and indium, gallium, aluminum, ,and thallium from column III elements can create interband and intrsuband lasers and detectors based on quantum-dot (QD) or type-II superlattice (T2SL). These are fast becoming the choice of technology in crucial applications such as environmental monitoring and space exploration. Last but not the least, on the far-infrared end of the electromagnetic spectrum, also known as the terahertz (THz) region, III-V semiconductors offer a unique solution of generating THz waves in a compact device at room temperature. Continued effort is being devoted to all of the above mentioned areas with the intention to develop smart technologies that meet the current challenges in environment, health, security, and energy. This talk will highlight my contributions to the world of III-V semiconductor Nano scale optoelectronics. Devices from deep UV-to THz.

Brief Biography of the Speaker: Manijeh Razeghi received the Doctorat d'État es Sciences Physiques from the Université de Paris, France, in 1980.
After heading the Exploratory Materials Lab at Thomson-CSF (France), she joined Northwestern University, Evanston, IL, as a Walter P. Murphy Professor and Director of the Center for

ISBN: 978-1-61804-224-8

Quantum Devices in Fall 1991, where she created the undergraduate and graduate program in solid-state engineering. She is one of the leading scientists in the field of semiconductor science and technology, pioneering in the development and implementation of major modern epitaxial techniques such as MOCVD, VPE, gas MBE, and MOMBE for the growth of entire compositional ranges of III-V compound semiconductors. She is on the editorial board of many journals such as Journal of Nanotechnology, and Journal of Nanoscience and Nanotechnology, an Associate Editor of Opto-Electronics Review. She is on the International Advisory Board for the Polish Committee of Science, and is an Adjunct Professor at the College of Optical Sciences of the University of Arizona, Tucson, AZ. She has authored or co-authored more than 1000 papers, more than 30 book chapters, and fifteen books, including the textbooks Technology of Quantum Devices (Springer Science+Business Media, Inc., New York, NY U.S.A. 2010) and Fundamentals of Solid State Engineering, 3rd Edition (Springer Science+Business Media, Inc., New York, NY U.S.A. 2009). Two of her books, MOCVD Challenge Vol. 1 (IOP Publishing Ltd., Bristol, U.K., 1989) and MOCVD Challenge Vol. 2 (IOP Publishing Ltd., Bristol, U.K., 1995), discuss some of her pioneering work in InP-GaInAsP and GaAs-GaInAsP based systems. The MOCVD Challenge, 2nd Edition (Taylor & Francis/CRC Press, 2010) represents the combined updated version of Volumes 1 and 2. She holds 50 U.S. patents and has given more than 1000 invited and plenary talks. Her current research interest is in nanoscale optoelectronic quantum devices.

Dr. Razeghi is a Fellow of MRS, IOP, IEEE, APS, SPIE, OSA, Fellow and Life Member of Society of Women Engineers (SWE), Fellow of the International Engineering Consortium (IEC), and a member of the Electrochemical Society, ACS, AAAS, and the French Academy of Sciences and Technology. She received the IBM Europe Science and Technology Prize in 1987, the Achievement Award from the SWE in 1995, the R.F. Bunshah Award in 2004, and many best paper awards.

ISBN: 978-1-61804-224-8

ISBN: 978-1-61804-224-8

An Assessment of Self-Organizing Maps and k-means Clustering Approaches for Atmospheric Circulation Classification

Despina Deligiorgi, Kostas Philippopoulos, and Georgios Kouroupetroglou

***Abstract*—** This study presents an analysis and comparison between the application of self-organizing maps (SOM) and the k-means clustering approaches in the field of atmospheric circulation classification, focusing in the area of southeastern Europe. Circulation type classification is a significant aspect of climate research in terms of examining the large-scale atmospheric variability and its relationship with local climate parameters. The study utilizes mean daily sea level pressure (MSLP) data for the spring months of a 62-year period (1948 to 2009) on a grid with 2.5^ox2.5^o resolution. Both schemes provide realistic classifications, differentiating in the number of the resulting circulation patterns. The two methods are compared by examining the distribution of each SOM circulation type members (days) to every k-means type and by investigating the pressure field correspondence along with their frequencies of occurrence. High similarity is observed, especially for the patterns where atmospheric circulation is controlled from high-pressure barometric systems. The SOM method is found to be superior, due to its ability to generate a non-linear classification and produce a map where closely related atmospheric modes are described by neighboring neurons and positioned in adjacent locations.

***Keywords*—** atmospheric circulation classification, data clustering, k-means clustering, Self-Organizing Maps.

I. Introduction

SYNOPTIC climatology is defined as the linkage of atmospheric circulation and environmental response [1] and is often based on the successful classification of atmospheric conditions into a number of different representative states [2]. The procedure is called circulation type classification and deals with a small number of discrete circulation types for analyzing the variability of atmospheric circulation in terms of their frequency changes on different temporal and spatial scales [3]. The classification schemes can be subdivided into subjective and automated methods, depending on the procedure that is used to assign atmospheric fields into the resulting classes. The subjective or manual schemes employ the expert's knowledge for identifying the atmospheric circulation types and are typically based on the visual analysis of daily weather maps. On the contrary, automated classification schemes essentially employ statistical methods for analyzing atmospheric data, with the objective of generating groups of cases with increased internal similarity and at the same time increased external separability. An extensive database of weather and automated circulation type classification schemes in Europe is presented in [4]. According to Huth [5] the automated methods can be further classified into the following categories:

- Correlation method
- Sum-of-squares method
- Cluster analysis methods
- Principal components analysis.

The objective of this work is to examine and compare the resulting patterns from two different cluster analysis approaches by examining their correspondence using qualitative and quantitative criteria. The adopted methodology along with the essential theoretical background of the classification schemes is analyzed in the second section of this work, while the resulting circulation patterns and their comparison in the third part of this paper. In the concluding part of this work the results are discussed and a two-step classification scheme, based on the strengths and weaknesses of the two approaches, is proposed.

II. METHODS

A. Area of study and data

In this study and for classifying atmospheric circulation, mean daily averaged sea level pressure (MSLP) data are acquired from the NCEP/NCAR Reanalysis 1 project [6] that produces a global analyses record of atmospheric fields. The reanalysis dataset covers the period from 1948 to 2009 on a grid with a 2.5^ox2.5^o resolution. The selected spatial domain is from 30^oN to 60^oN and from 10^oW to 37.5^oE, which contains 260 grid points in total. The classification is performed for the transitional period of spring (March to May), leading to a subset of 5704 MSLP fields (days). In southeastern Europe, spring is one of the most significant seasons in terms of

This work was partially funded by the National and Kapodistrian University of Athens, Special Account for Research Grants.

D. Deligiorgi is with the Division of Environmental Physics and Meteorology, Department of Physics, National and Kapodistrian University of Athens, GR15784, Athens, Greece (corresponding author, phone: +30 2107276924; fax: +30 2106018677; e-mail: despo@phys.uoa.gr).

K. Philippopoulos with the Division of Environmental Physics and Meteorology, Department of Physics, National and Kapodistrian University of Athens, Greece (e-mail: kostasphilippopoulos@yahoo.com).

G. Kouroupetroglou is with the Division of Signal Processing and Communication, Department of Informatics and Telecommunications, National and Kapodistrian University of Athens, GR 15784 Athens, Greece (e-mail: koupe@di.uoa.gr).

atmospheric circulation as the weather alternates from cold to warm period types. The clustering algorithms treat each of the 5704 days as a different object while the 260 grid point MSLP values are the elements (variables) of each object.

B. Methodology

The atmospheric circulation for the period and area under study is examined using two different clustering approaches. The first classification scheme employs a traditional clustering algorithm (k-means). The k-means method is the most widely known data-clustering scheme and has been extensively used in environmental sciences for grouping objects into respective categories (e.g. [7] and [8]). It is a nonhierarchical clustering approach with the inherent advantage of allowing the reallocation of misplaced objects as the analysis proceeds [9]. The method defines k centroids, one for each cluster, and associates each object to the nearest centroid. It uses an iterative algorithm that finds the local minimum of the sum of object-to-centroid Euclidean distances, summed over all k clusters according to:

$$J = \sum_{j=1}^{k} \sum_{i=1}^{n} \left\| \overrightarrow{x_i} - \overrightarrow{c_j} \right\| \qquad (1)$$

where $\left\| \overrightarrow{x_i} - \overrightarrow{c_j} \right\|$ is the Euclidean distance of the object $\overrightarrow{x_i}$ and the centroid $\overrightarrow{c_j}$.

The k-means method consists of two steps. Initially the Principal Components Analysis (PCA) is used to reduce the dimensionality of the dataset and subsequently the k-means clustering is performed. The PCA method transforms the high-dimensional space into fewer dimensions and in our case the initial 5704x260 dataset is reduced to a 5704x25 subset by using the first 25 principal components that describe the 99.01% of the total variation. This pre-processing step is essential for the efficient classification of MSLP data.

The second approach is the Self-Organizing Map (SOM) algorithm, introduced by Kohonen [10], which is an unsupervised neural network model used for classification and feature extraction of high-dimensional data. The SOM converts the complex, nonlinear statistical relations of the high-dimensional input data into simple geometric relations at a typically two-dimensional map [11]. Such a property is highly desirable in meteorology and synoptic climatology, where the nonlinearity is a primary characteristic of atmospheric field data [12]. A detailed survey of SOM applications in meteorology and oceanography is presented in [13], while a description of its applications in climate studies can be found in [14]. The SOM neural network model consists of an input layer and a two-dimensional lattice of neurons, the output or competitive layer, which is fully connected to the input space. Initially the number of neurons is selected and their weight vectors are randomly initialized. Subsequently a training vector is presented to the network and the Euclidean distances between the training vector and the neurons' weight vectors are calculated. The neuron that produces the smallest distance is called the Best Matching Unit (BMU) and its weight vectors along with its neighboring neurons weight vectors are updated towards the input vector. The input vectors are presented sequentially in the network and by using iterative training the neurons are adjusted in a way that different parts of the SOM respond similarly to certain input patterns. The final part of the SOM method is the visualization of the results, where each training vector is associated with one neuron, which represents the resulting patterns of the classification process. According to Haykin [15], the main properties of the SOM lattice are:

- The approximation of the input space, as it is estimated from the weight vectors
- Topological ordering, where a location within the lattice corresponds to a specific feature of the input patterns
- Density matching, as more neurons are allocated to represent dense areas of the input space
- Feature selection as the method selects the best features to approximate the underlying distribution.

The SOM methodology has been applied in southeastern Europe for associating wintertime precipitation and large-scale atmospheric variability [16] and for identifying synoptic patterns based on 500hpa level geopotential height [12].

The main drawback of both classification schemes is the requirement of a predefined number of clusters. In circulation type classification there is no a priori knowledge of the number of the resulting patterns and therefore both methods are repeated for a range of initial number of classes. In detail, for the k-means classification the procedure is repeated multiple times for centroids ranging from 6 to 13, while for the SOM classification for two-dimensional lattices that correspond to classes ranging from 12 to 36, with varying number of row and column neurons. The optimum number in both cases is selected from the qualitative examination of the resulting composite MSLP maps.

III. RESULS

A general remark from the multiple experiments of generating atmospheric circulation types from both classifications is that in many cases the resulting MSLP composites were suboptimal. The qualitative analysis of the resulting patterns identified an optimum number of ten clusters for the k-means classification (Figure 1) and twenty atmospheric states for the SOM classification (Figure 3), which are mapped along a 4-row and 5-column hexagonal topology. The relative frequencies of each type in both cases are presented in Figure 2 and Figure 4 respectively.

A. k-means circulation patterns

The k-means circulation classification (Figure 1) resulted into two types influenced by low-pressure systems (K1 and K2 types), in two patterns characterized by high-pressure systems (K3 and K4 types), in three smooth fields with minimal pressure gradient (K5, K6 and K7 types) and in three states where the atmospheric circulation is influenced by both high and low pressure systems (K8, K9 and K10 types). The description of the relevant circulation patterns is presented in terms of the most important atmospheric circulation characteristics in Table 1 and their relative frequencies of occurrence in Figure 2.

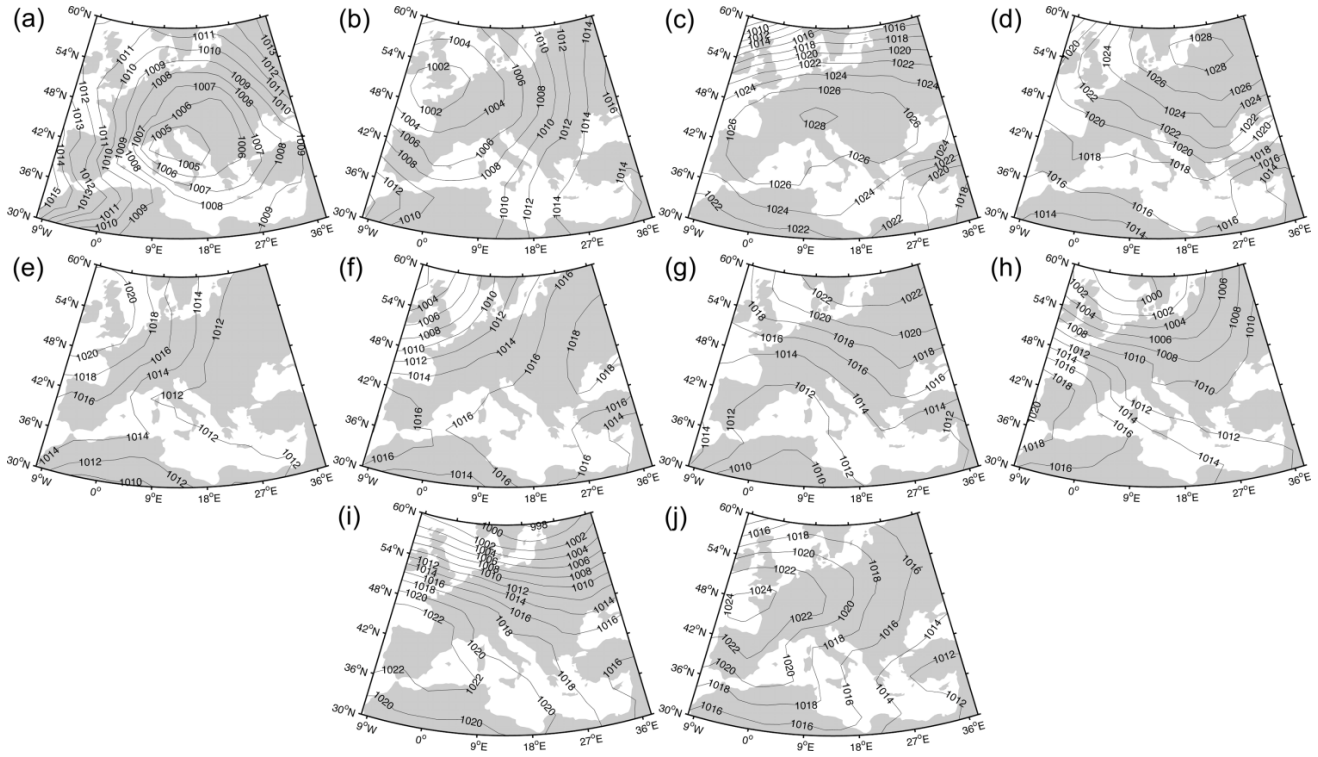


Fig. 1 The k-means classification circulation types, K1 (a), K2 (b), K3 (c)

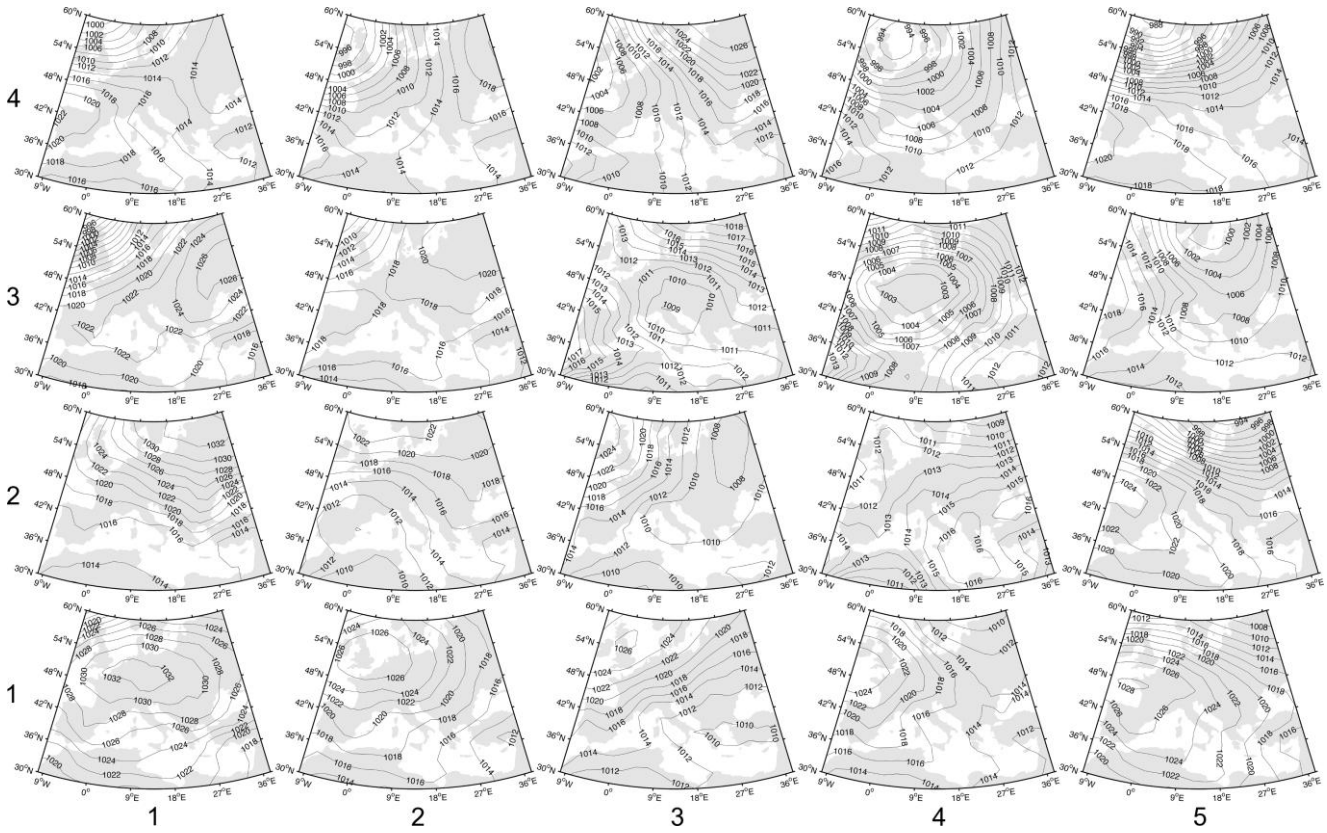


Fig. 3 The SOM classification circulation types

Table 1: Description of the k-means classification circulation types

Abbreviation	Circulation type	Description
K1	Cyclonic	Low-pressure system over central Italy
K2	Cyclonic	Low-pressure system over the British Isles
K3	Anticyclonic	Extended anticyclone over central Europe
K4	Anticyclonic	Extension of the Siberian anticyclone over western Russia and the Baltic countries
K5	Smooth	Smooth pressure field that favor the development of local flows
K6	Smooth	Smooth pressure field that favor the development of local flows
K7	Smooth	Smooth pressure field that favor the development of local flows
K8	High – Low combination	Low-pressure system in northern Europe over Nordic countries - Anticyclone in the Iberian Peninsula
K9	High – Low combination	Low-pressure system in northern Europe over Nordic countries - Anticyclone in the Iberian Peninsula
K10	High – Low combination	Easterly extension of the Azores anticyclone in western and central Europe in combination with the low-pressure field in the Middle East

Table 2: Description of the SOM classification circulation types

Abbreviation	Circulation type	Description
SOM1.1	High – Low Combination	Combination of the extended anticyclone in central Europe and the relative low-pressure field of the Middle East
SOM2.1	High – Low Combination	Combination of the extended anticyclone over the UK and the Netherlands and the relative low-pressure field of the Middle East
SOM3.1	Cyclonic	Relative low-pressure field over Greece and the Balkans
SOM4.1	High – Low Combination	High and low pressure fields at the west and east of Greece respectively
SOM5.1	Anticylconic	Anticyclone at the north of the Iberian peninsula which extends over the whole Mediterranean Sea
SOM1.2	Anticylconic	Anticyclone in northern Europe at the Baltics which extends over the Balkans and Greece
SOM2.2	Smooth	Smooth field that favor the development of local flows
SOM3.2	Smooth	Smooth field that favor the development of local flows
SOM4.2	Smooth	Smooth field that favor the development of local flows
SOM5.2	Anticylconic	High-pressure system in the Iberia peninsula which extends over the eastern Mediterranean
SOM1.3	Anticylconic	The Siberian anticyclone is extended over the Balkans
SOM2.3	Smooth	Smooth pressure field for the entire European continent
SOM3.3	Cyclonic	Low-pressure system of the Adriatic Sea and Italy
SOM4.3	Cyclonic	Extended low-pressure system over central Europe.
SOM5.3	Cyclonic	Low-pressure in northeastern Europe
SOM1.4	Anticylconic	Weak Azores high penetration in the eastern Mediterranean that favors the development of local flows
SOM2.4	Cyclonic	Deep low in the UK does not affect Southeastern Europe
SOM3.4	High – Low Combination	High-low combination over Western and Eastern Europe
SOM4.4	Cyclonic	Deep low-pressure system situated at North Sea
SOM5.4	Cyclonic	Low-pressure system, located at the north of Greece

ISBN: 978-1-61804-224-8

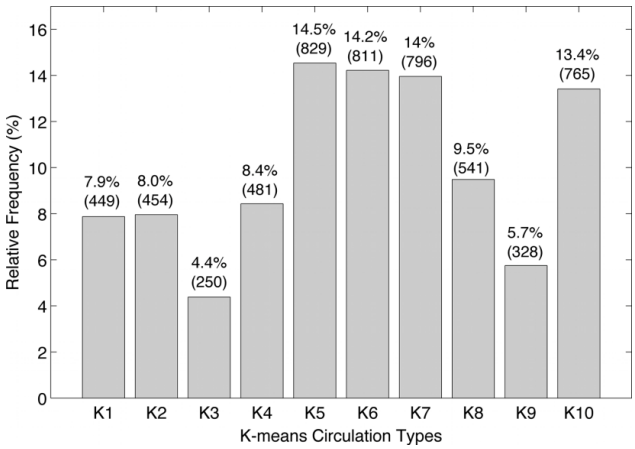


Fig. 2 Relative (and absolute) frequency of occurrence of the k-means classification circulation types

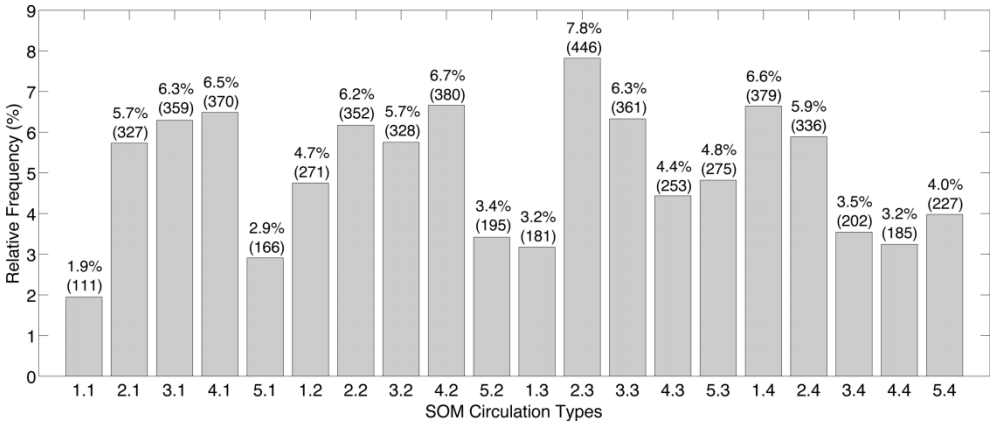


Fig. 4 Relative (and absolute) frequency of occurrence for the SOM classification circulation types

Table 3: Agreement in percent between the SOM and the k-means circulation patterns

	K1	**K2**	**K3**	**K4**	**K5**	**K6**	**K7**	**K8**	**K9**	**K10**
SOM1.1	0.0	0.0	**76.6**	21.6	0.0	0.0	0.0	0.0	0.0	1.8
SOM2.1	0.0	0.0	1.5	33.0	0.0	0.0	4.0	0.0	0.0	61.5
SOM1.3	1.7	0.0	0.0	0.3	**50.1**	0.0	30.4	0.0	0.0	17.5
SOM1.4	0.0	0.0	0.0	0.3	39.2	1.6	3.2	0.5	2.4	52.7
SOM1.5	0.0	0.0	44.6	2.4	0.0	0.0	0.0	0.0	19.3	33.7
SOM2.1	0.0	0.0	0.4	**80.8**	0.0	0.0	17.7	0.0	0.0	1.1
SOM2.2	0.6	0.3	0.0	4.8	4.0	1.1	**88.9**	0.0	0.0	0.3
SOM2.3	22.0	1.5	0.0	0.0	**74.4**	0.0	1.5	0.0	0.6	0.0
SOM2.4	1.3	11.1	0.0	0.0	22.4	49.2	6.3	6.1	1.8	1.8
SOM2.5	0.0	0.0	2.1	0.0	1.5	0.0	0.0	10.3	**85.1**	1.0
SOM3.1	0.0	0.0	44.2	16.0	0.0	29.8	0.0	0.0	2.2	7.7
SOM3.2	0.0	0.0	0.2	15.9	1.3	30.7	17.3	0.0	0.0	34.5
SOM3.3	31.0	5.3	0.0	0.0	32.4	7.5	19.1	3.9	0.0	0.8
SOM3.4	44.3	52.6	0.0	0.0	0.0	0.0	0.0	3.2	0.0	0.0
SOM3.5	24.4	8.0	0.0	0.0	6.2	0.0	0.0	59.6	1.8	0.0
SOM4.1	1.8	0.0	0.0	0.0	4.7	41.2	0.0	25.3	10.0	16.9
SOM4.2	5.7	31.3	0.0	0.0	0.0	55.7	0.6	6.8	0.0	0.0
SOM4.3	9.4	14.9	0.0	3.5	0.0	10.9	61.4	0.0	0.0	0.0
SOM4.4	15.1	**51.4**	0.0	0.0	0.0	0.0	0.0	**33.5**	0.0	0.0
SOM4.5	0.0	0.9	0.0	0.0	0.0	13.7	0.0	56.8	28.6	0.0

ISBN: 978-1-61804-224-8

B. SOM circulation patterns

The circulation patterns of the SOM classification are mapped according to the influence of the high and low-pressure systems (Fig. 3). The description of the relevant SOM circulation patterns is presented in terms of the most important atmospheric circulation characteristics in Table 2 and their relative frequencies of occurrence in Figure 4. In the lower left part of the map the patterns are mainly influenced by the existence of high-pressure systems in Europe, while the relative location of the low-pressure systems is the primary characteristic of the upper right part. This finding is in accordance with previous studies [14] and it is attributed to the inherent characteristic of the SOM method to self-organize. The nodes (neurons) exist in a continuum and enable the understanding of phases as well as the transitional nodes between phases [2].

C. Comparison of the atmospheric circulation classifications

The two classification schemes produce similar circulation types. The comparison of two classifications is presented in terms of examining the distribution of each SOM circulation type days to the k-means patterns (Table 3). Regarding the circulation types that are characterized from the existence of a low-pressure system in Europe, the SOM3.3 and the SOM3.4 types share common characteristics with K1 circulation type, differentiating in the relative position of the low-pressure system. Furthermore, 84.9% of the SOM4.4 days are classified as members of the K2 and K8 types, while the surface pressure distribution of the SOM3.5, SOM4.5 and the K8 types is depicted from the existence of a low-pressure system in northern Europe. The characteristic synoptic condition of the SOM2.5 is almost identical to the K9 type, resulting to a high agreement percentage (85.1%). For both classifications an increased number of days are classified into smooth pressure patterns with minimal pressure gradient in southeastern Europe. In detail, the days classified into the SOM1.3 and SOM2.3 patterns have high agreement percentages with the K5 circulation type (50.1% and 74.4% respectively), while the SOM2.4, SOM4.1 and SOM4.2 patterns are similar to the K6 circulation type. The SOM2.2 type is almost identical with the K7 pattern, with a total agreement of 88.9%. The two classification schemes provide more consistent results for the high-pressure system patterns. The SOM1.1 and SOM1.5 types, due to their cold period character, are mainly observed during March and are similar to the K3 type. Furthermore, high agreement percentage (80.8%) is observed between the SOM2.1 and the K4 types, which are also commonly observed during March. The synoptic situation for both SOM1.2 and SOM1.4 types share some common characteristics with the K10 pattern, where an anticyclone is located at the north of the Iberian Peninsula and in the British Isles. The similarity between the resulting patterns of the two classifications is further established from the high correspondence of their monthly frequency of occurrence.

IV. CONCLUSIONS

In this study two automated atmospheric circulation classification schemes are presented and examined for their ability to produce meaningful circulation types for the spring season in southeastern Europe. Both classifications, following the circulation-to-environment approach, can be used for relating the circulation types with regional or local scale meteorology and climatology. The k-means classification includes ten distinct types, while the SOM required more neurons to describe with discrete atmospheric states the daily MSLP distribution for the area and period under study. Both methods (k-means and SOM) are designed to achieve optimal distribution of objects (daily patterns) into the classes. The reason for reaching different result is that k-means can be trapped in local minima of the minimization function (reduction of within-type variance) while SOM is able to approach the global optimum. Meaningful relations are obtained in all cases. The correspondence of the two classifications is higher for the types where the high-pressure systems define the atmospheric circulation in the examined region. The SOM scheme has the ability to account for non-linear relationships and produce a map where synoptic states that are closely related are positioned in adjacent locations. In our case the high-pressure patterns are positioned in the lower left part of the map while the low-pressure patterns are located in the upper right part. Future work is proposed for developing a two-step classification scheme using both of the examined methods. The SOM can be used to decrease and reduce noise by producing a high number of atmospheric states which can be subsequently further grouped into a highly practical daily catalogue by applying k-means cluster analysis.

REFERENCES

[1] B. Yarnal, *Synoptic Climatology in Environmental Analysis: A Primer*. London: Belhaven Press, 1993, 1st edition.

[2] C. S. Sheridan, and C. C. Lee, "The self-organizing map in synoptic climatological research", *Prog. Phys. Geog.*, vol. 35, pp. 109-119, 2011.

[3] C. Beck, and A. Philipp, "Evaluation and comparison of circulation type classifications for the European domain". *Phys Chem Earth, Parts A/B/C*, vol. 35 (9-12), pp. 374-387, 2010.

[4] A. Philipp, J. Bartholy, C. Beck, M. Erpicum, P. Esteban, X. Fettweis, R. Huth, P. James, S. Jourdain, F. Kreienkamp, T. Krennert, S. Lykoudis, S. C. Michaelides, K. Pianko-Kluczynska, P. Post, D. Rasilla Álvarez, R. Schiemann, A. Spekat, and F. S. Tymvios, "Cost733cat – A database of weather and circulation type classifications". *Phys. Chem. Earth, Parts A/B/C*, vol. 35 (9-12), pp. 360-373, 2010.

[5] R. Huth, "An intercomparison of computer-assisted circulation classification methods". *Int. J. Clim.*, vol. 16, pp. 893-922, 1996.

[6] E. Kalnay, M. Kanamitsu, R. Kistler, W. Collins, D. Deaven, L. Gandin, M. Iredell, S. Saha, G. White, J. Woollen, Y. Zhu, A. Leetmaa, R. Reynolds, M. Chelliah, W. Ebisuzaki, W. Higgins, J. Janowiak, K. C. Mo, C. Ropelewski, J. Wang, R. Jenne, and D. Joseph, "The NCEP/NCAR 40-year reanalysis project". *Bull. Amer. Meteor. Soc.*, vol. 77, pp. 437-447, 1996.

[7] W. Enke, and A. Spekat, 1997. "Downscaling climate model outputs into local and regional weather elements by classification and regression". *Clim. Res*., vol. 8, pp. 195–207, 1997.

[8] G. Karvounis, D. Deligiorgi, and K. Philippopoulos, "On the sensitivity of AERMOD to surface parameters under various anemological conditions". In Proceedings of the 11th International Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes, pp. 43-47, 2007.

[9] D. S. Wilks, 2011. *Statistical Methods in the Atmospheric Sciences*. Amsterdam: Academic Press, 2011, 3rd edition.

[10] T. Kohonen, *Self-Organization and Associative Memory*. New York: Springer-Verlag, 1984, 3rd edition.

[11] T. Kohonen, T., *Self-Organizing Maps*. New York: Springer-Verlag, 2001, 3rd edition
[12] S. C. Michaelides, F. Liassidou, and C. N. Schizas, "Synoptic classification and establishment of analogues with artificial neural networks". *Pure Appl. Geophys.*, vol. 164, pp. 1347-1364, 2007.
[13] Y. Liu, and H. R. Weisberg, "A Review of Self-Organizing Map Applications in Meteorology and Oceanography", In *Self Organizing Maps - Applications and Novel Algorithm Design*, Rijeka: InTech Publishers, 2011.
[14] B. C. Hewitson, and R. G. Crane, "Self-organizing maps: applications to synoptic climatology". *Clim. Res.*, vol. 22, pp. 13-26, 2002.
[15] S. Haykin, *Neural Networks and Learning Machines*. Upper Saddle River: Pearson Education Inc., 2009, 3rd edition.
[16] T. Cavazos, "Using Self-Organizing Maps to Investigate Extreme Climate Events: An Application to Wintertime Precipitation in the Balkans". *J. Climate*, vol. 13, pp. 1718-1732, 2000.

An Environmental Monitoring Plan related to the laying of marine power cables: the case study of SAPEI project

O. Nonnis, C. Maggi, T. Bacci, A. Izzi, F. Massara, F. S. Rende, B. Trabucco, and M. Gabellini

***Abstract*—**Coastal areas are complex systems where both marine ecosystems and human activity interrelate, often raising several conflicts. The economic activities may, sometimes, disturb the functioning and stability of coastal ecosystems, particularly of the seagrass meadows or sensitive ecosystems, and menace their future existence. In this work we present the environmental study carried out in three landing areas (NW Sardinia and Latium coasts -Italy), where three marine power cables were laid from 2007 to 2010. The technical project, named SAPEI, provided the electrical connection between Sardinian and Latium coast through the Tyrrhenian Sea. Environmental investigations were carried out before, during and after cables installation in order to understand and define how cable laying can interact with seabed. SAPEI has permitted us to gain a high amount of data, which will allow to optimize the field and laboratory work in future monitoring plans.

***Keywords*—**Environmental monitoring, marine power cables, Tyrrhenian Sea.

I. Introduction

THE global growing demand for energy and the need to connect mainland with offshore environments are forcing energy companies to enhance their underwater cable and pipelines networks in order to allow an effective, continuous and reliable transport of energy resources. The progress made in underwater cable technology, the quick rate of return on the investments made and the capacity to source energy from hydroelectric or wind facilities have made these underwater pipeline/cable connections very attractive, proving that this is by far the most cost effective way for transporting crude oil, natural gas and their products over very large distances [1].

However, the installation of these infrastructures must take into account the possible environmental disturbing actions, such as the excavation activities for cables burial. The main impacts associated with this kind of infrastructures are: the removal or temporary modification of biocoenosis in the area of interest, the increased turbidity and the possible remobilisation of hazardous substances, the decrease of photosynthetic activity and, in general, all disturbance activities on marine organisms [2]. The cables, once in the bottom, are not dangerous for the marine environment, therefore during the terminal operation phase its presence should not lead to significant alterations.

Hence, it becomes clear that any type of underwater or coastal project requires an in-depth and solid knowledge of the physical and biological processes taking place in these environments [3].

This is the context for the environmental characterization and monitoring activities carried out following the realization of a large-scale human work, such as the installation of submarine power lines of the SAPEI Project.

In this work we present and describe the SAPEI Monitoring Plan carried out between 2007 and 2011. This plan provides the application of an integrated approach in order to analyze the possible environmental alterations that may occur in marine environment.

II. The SAPEI Project

The new long-distance power line SA.PE.I– acronym of SArdegna-PEnisola-Italiana –consists in a double DC 500kV submarine cable having a total capacity of 1,000 MV, between Sardinia and Latium, realized by Terna S.p.A. from 2007 to 2010 (Table I). The SA.PE.I connection is composed of two power cables 420 km long, that cross Tyrrhenian Sea until the maximum depth of 1640 meters, and two electrode cables: the anode (Sardinia) and cathode (Latium).

The SAPEI project was approved with mandatory requirements and, therefore, Terna had to elaborate and execute an environmental monitoring plan for the interested marine area, with special regard to the seagrass meadows. Terna charged ISPRA (Italian National Institute for Environmental Protection and Research) to develop and carry out the environmental monitoring of the marine areas interested by the cables route.

O. N. is with the Institute for Environmental Protection and Research, ISPRA, Rome (Italy) (e-mail: ornella.nonnis@isprambiente.it).

C. M. is with the Institute for Environmental Protection and Research, ISPRA, Rome (Italy) (e-mail: chiara.maggi@isprambiente.it).

T. B. is with the Institute for Environmental Protection and Research, ISPRA, Rome (Italy) (e-mail: tiziano.bacci@isprambiente.it).

A. I. is with the Institute for Environmental Protection and Research, ISPRA, Rome (Italy) (e-mail: alessia.izzi @isprambiente.it).

F. M. is with the TERNA S.p.A, Rome (Italy) (e-mail: francesca.massara@terna.it).

F. S. R. is with the Institute for Environmental Protection and Research, ISPRA, Rome (Italy) (e-mail: francesco.rende@isprambiente.it).

B.T. is with the Institute for Environmental Protection and Research, ISPRA, Rome (Italy) (e-mail: benedetta.trabucco@isprambiente.it).

M. G. is with the Institute for Environmental Protection and Research, ISPRA, Rome (Italy) (e-mail: Massimo.gabellini@isprambiente.it).

DOI: 10.2112/SI65-xxx.1 received Day Month 2012; accepted Day Month 2013.

ISBN: 978-1-61804-224-8

In these coastal areas, near the landing points (Fiume Santo, Punta Tramontana, Nettuno), cables were laid on the seabed and anchored with appropriated devices, placed manually by SCUBA divers in order to avoid seagrass damage and prevent further cable sliding on the seabed.

Whereas beyond the lower limit of phanerogam meadows, cables were buried to a depth of approximately 700 m.

Table I. Main construction phases (laying or burial works) in the landing areas affected by the Sapei project. FS = Fiume Santo, PT= Punta Tramontana, NT= Nettuno.

Site	Cable	Times
FS	Electrode anode	December 2007, April 2008, June 2008
	Power cables Polo 1	April 2008, June 2008
	Power cables Polo 2	April 2010, May2010
PT	Electrode anodo	December 2007, September 2008
NT	Electrode cathode	December 2007
	Power cables Polo 1	September 2008, October2008
	Power cables Polo 2	June 2010, July 010

III. The Study Area

The environmental monitoring project concerned the coastal areas of three different landing points (Fig. 1), two of which located in north-east Sardinia (Fiume Santo and Punta Tramontana) and the third located in Latium coast (Nettuno).

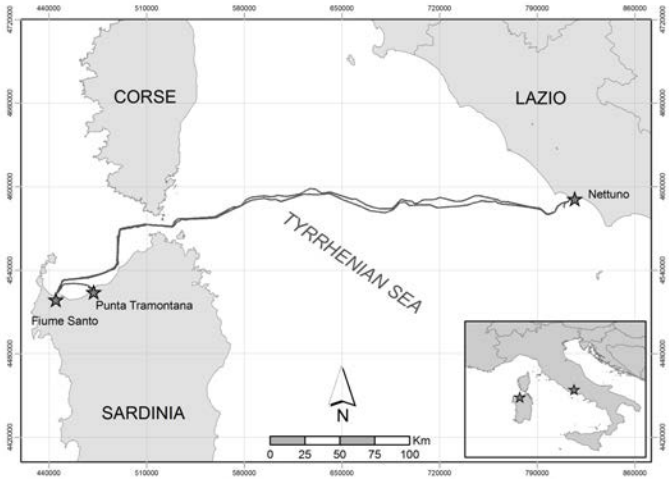


Fig. 1. Areas interested from SAPEI project between Sardinia and Latium (Tyrrhenian Sea).

Fiume Santo landing area is interested by the presence of three cables (Pole 1, Pole 2 and anode). The sea bottoms are generally flat and sandy, with scattered outcrops of bedrock. *Posidonia oceanica* meadows extend from the sandy shores seaward, from 6 down to a depth of 30 metres. The cables cross the prairie in an area 2,7 nautical miles long and 0,5-0.9 nautical miles large. The coast is characterised by the presence of several industrial sites mostly dedicated to the production of chemicals, and of hydrocarbon and LPG storage facilities.

Punta Tramontana landing area is affected by the presence only of the anode cable. Along its route, from 2 m. depth, we find a *P. oceanica* area with a highly discontinuous distribution on hard substrate, dead *matte* patches on a bottom made up of boulders and pebbles, and large sandy patches with sparse tufts near its lower limit, located at a depth of about 28 m.

Nettuno landing area is affected by the presence of three cables (Pole 1, Pole 2 and cathode). Until the depth of 15 m the seafloor is marked by thin and very thin sands and is colonized by *Cymodocea nodosa*, which forms sparse and irregular patches, but nevertheless contributing to the substrate stabilisation. The investigated area is characterized by strong human pressure, along the coastline there are Anzio and Nettuno harbours, and many coastal protection works.

IV. The Philosophy of Monitoring Plan

The Monitoring Plan was drawn up in compliance with the provisions which authorised the cable installation (CIPE resolution no. 144/2005). Consistently with these provisions, short- and long-term inspections were planned for checking the health status of a biological quality element such as *P. oceanica* meadow, and of some physico-chemical and ecological quality elements in water column and sediment, considered as relevant environmental descriptors for the assessment of potential effects of cable-laying and support parameters for the biological quality elements.

Considering the complexity of the activities, which included three distinct laying activities in the Fiume Santo and Nettuno landing areas and a single construction phase in Punta Tramontana, this Monitoring Plan was structured foreseeing: i) *ante operam* investigations for the study of the marine environment (2007), ii) a subsequent and wide monitoring phase during the laying works (2008, 2009, 2010) and iii) a final phase of the study at the end of the works (2010-2011). So, in accordance with the authorization requirements, the final evaluation of the environment health state provided important information on physical-chemical, biological and ecological elements in water column, in sediment and seagrass meadows.

The *ante operam* phase included a series of initial investigations aimed at understanding and defining the environment involved, for the refinement of the monitoring activities during and/or subsequent to the various construction phases. Quality and quantity surveys were carried out in areas presenting *P. oceanica* or *C. nodosa* meadows, as well as physical-chemical and ecotoxicological surveys of sediments, and water column and soft bottoms macrozoobenthos sampling.

The monitoring phase during the laying works begun immediately after the *ante operam* phase. In accordance with the authorization requirements, surveys on Sardinian *P. oceanica* meadows were conducted every four months, with an initially planned monitoring period of 24 months, extended to 33 months in Punta Tramontana and to 42 months in Fiume Santo. In Nettuno the sampling on *C. nodosa* praire was

ISBN: 978-1-61804-224-8

conducted less frequently, also due to the limited extension of the meadow itself. Furthermore, during this phase, samplings for physic-chemical and ecotoxicological assessment of sediments and for the study of soft bottom macrozoobenthos communities were conducted in the three landing points.

In addition to the activities described above and simultaneously with the laying operations, specific surveys were carried out on the water column to assess the extent of the material resuspended during the laying activities which could cause impacts on *P. oceanica* meadows and on *C. nodosa* prairie. The construction activities which could have a potential impact on the marine environment are those related to the gripping of the route (PLGR) and the burial of cables.

During the final phase of the study at the end of the works, the same investigations conducted during the "white phase" were carried out in the three landing points (with the exception of quantitative surveys on phanerogam meadows in Punta Tramontana and Nettuno), integrated with a study on morphological and bathymetric features of the seabed. These monitoring activities aim at assessing the extent of the impact of cable laying after a defined period of time from the end of laying activities.

V. THE SAPEI MONOTORING PLAN

The SAPEI Monitoring Plan was conceived as an integrated plan. In order to give the best description of the environmental quality status an integrated approach was applied by means of physical and chemical analyses, ecotoxicological assays, ecological and acoustic investigations. Matching these information, the plan tried also to identify spatial-temporal trends of the possible alteration that could occur in relation with the project.

Below we describe the matrices investigated and the sampling strategy adopted for the sites affected by the power cables installation.

Fig 2, 3 and 4 show, for each landing point, the sampling stations of the matrices investigated and the areas covered by the geophysical surveys.

A. *Water column*

The water column has a significant role in spreading contaminants in the other marine sectors through dilution, dispersion and allocation processes. The investigations of physical-chemical parameters provide an essential knowledge base for studying the destination of pollutants released in the environment and for the water body quality assessment.

Physical-chemical parameters are monitored in situ by multiparametric CTD probe, equipped with additional specific sensors. Water samples for physical-chemical analyses (chlorophyll, nutrient) are collected using a "rosette" device equipped with Niskin bottles, sampling at different depths.

Water column investigations were carried out only once before and after construction phases; in the monitoring phase during the laying works (from 2007 to 2010) investigations on water column were carried out simultaneously with cable laying and burial operations; in Fiume Santo landing point water-column investigations were conducted also during the quantitative surveys on *Posidonia oceanica* meadow.

A. *Seagrasses*

The monitoring of seagrasses is always necessary before starting works whose location, structure and operations interfere with the meadow, through indirect impacts such as changes in hydrodynamic and increased turbidity of water column, or direct impacts with habitat destruction [4]. In this context, reference is made to the species *P. oceanica* (L.) Delile and *C. nodosa* (Ucria) Asch., since they represent the two most common species in Mediterranean coastal habitats [5]. They provide food for coastal food webs and oxygen to sediments and water column, they stabilize sediments, improve water transparency and attenuate waves protecting the coastline [6]. Therefore, the importance of taking these species as indicators of quality of the marine environments appears clear [7], [8]. In the SAPEI monitoring Plan, qualitative and quantitative surveys were performed along the cables routes in order to assess, over time (before, during and after the installation phase), the interactions between seagrasses and the power lines placed and anchored on its meadows. It is noted that in Punta Tramontata and in Nettuno landing areas the monitoring plan focused the attention on the qualitative surveys only, considering the small extent of these meadows. The research takes into account both direct and indirect actions on the meadows occurred during the installation phase, such as the possible increase of turbidity of the water due to sediment resuspension, especially in lower bathymetric range where the hydrodynamic action appears generally higher respect to deeper waters.

In particular, video-photographic monitoring activities were conducted through the use of a Remotely Operated Vehicle (R.O.V) along each cable route from the highest to the lowest limit of the meadow, maintaining a constant height from the bottom and a constant diving direction, in order to determine habitat boundaries and interferences of the cables on the bottom.

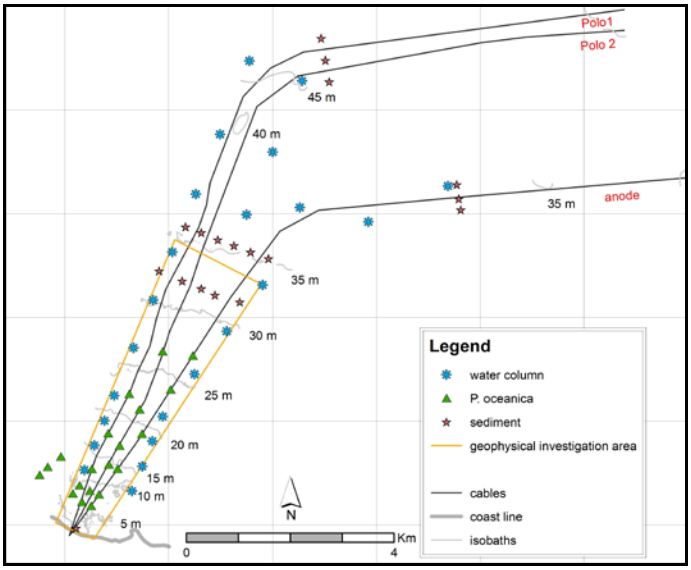


Fig. 2. Fiume Santo site: routing cables, sampling stations of water column, P. oceanica sediment and geophysical investigation area.

ISBN: 978-1-61804-224-8

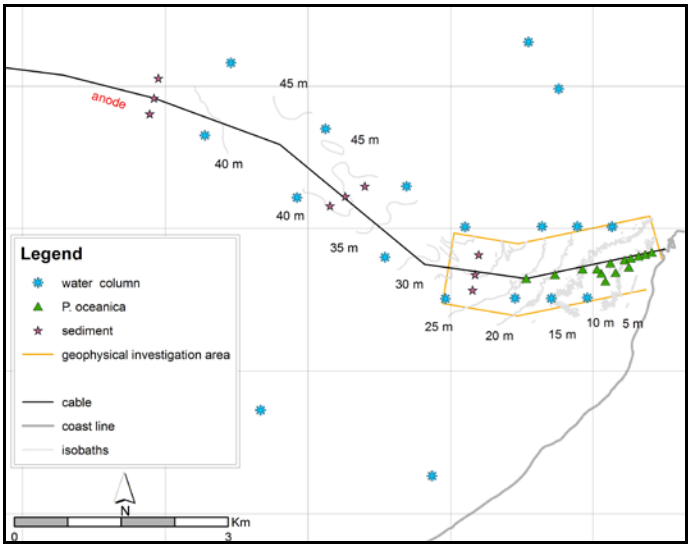


Fig. 3. Punta Tramontana site: routing cables, sampling stations of water, P. oceanica, sediment and geophysical investigation area.

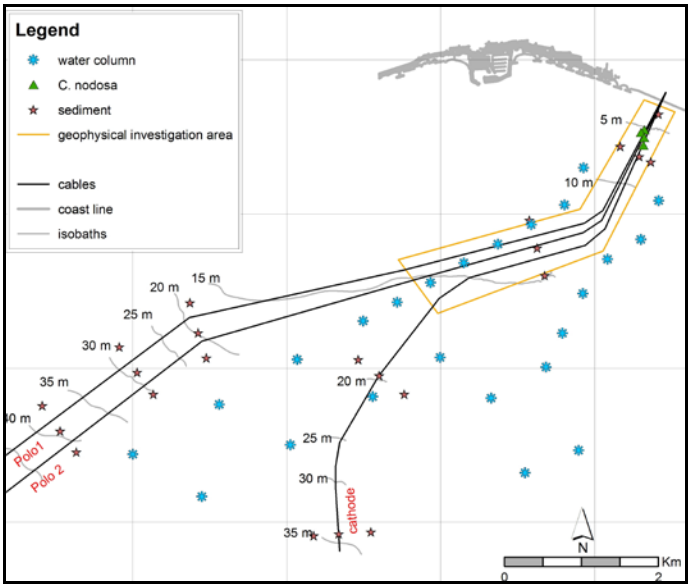


Fig. 4. Nettuno site: routing cables, sampling stations of water column, C. nodosa sediment and geophysical investigation area.

In addition, 20, 14 and 4 sampling stations were investigated by SCUBA divers in Fiume Santo, Punta Tramontana and Nettuno respectively. Shoot density were randomly counted in ten square frames of 40 cm in size around the station point [9]. Then, orthotropic shoots have also been haphazardly collected from each station for later phenological [10], lepidochronological [11], [12] and epiphytic community laboratory analysis, in order to investigate further functional and ecological aspects of the plants.

B. Sediment

Physical, chemical and ecotoxicological analysis

Sediments have an essential role for the health of aquatic ecosystems, functioning as habitat for many organisms and sustaining aquatic flora and fauna. They represent the sector where many chemicals are deposited, including dangerous, toxic, persistent and bioaccumulative contaminants. Several studies have demonstrated that high concentrations of contaminants in sediments are related to the concentrations found in interstitial water, which represent the dissolved fraction, thus being potentially more bioavailable.

Chemical, biological and ecotoxicological surveys are complementary approaches in assessing sediment quality, in defining a water body health state and in identifying possible spatial trends.

In each investigated areas sediment sampling was carried out once in the pre-construction phase and in the final phase of the study. Instead in the monitoring phase, during the laying works, sediments have been sampled after each cable installation.

Sediments were collected by a Van Veen grab at the different sampling stations, and treated and stored according to definite protocols. Grain size analysis, chemical (metals, PAH, PCBs, pesticides, organotin compounds and organic matter) and ecotoxicological analysis were performed to evaluate possible contamination and /or impact caused by construction and operation phases. Therefore, the chemical parameters investigated were selected taking into account the main impacts associated with cable installation. Furthermore, the chemical parameters were selected considering some important regulations on: a) seabed movement as a result of cables and pipelines laying, b) compliance with quality standards for sediments of coastal waters and c) protection of the aquatic environment.

Macrozoobenthos

Macrozoobenthic assemblages are composed by organisms establishing more or less close relation with the seafloor, varying in size from 0.5 mm to 1 mm. In these communities Polychaete Annelids, Mollusks, Amphipods and Decapod Crustaceans and Echinoderms dominate, both in number of species as in number of individuals.

The soft-bottom benthic assemblages play a key role in the coastal marine ecosystems, representing the biological memory and expressing such dynamics which allow an integrated spatio-temporal evaluation of the ecosystem modifications. The macrozoobenthos organisms are good indicators of the environmental stress, since because of the gravity force everything goes in the sedimentary division, also what comes from fresh waters; besides, the detritus chain, in which all organic and inorganic substances (also pollutants) coming from the water column enter, is the main energetic source of the benthic system. Through the bioturbation benthic organisms are able to circulate the xenobiotic substances mineralized in sediment.

The trophic-functional heterogeneity of species composing these communities and the presence of complex life cycles, often with a meroplanctonic phases, makes the study of the soft-bottom macrozoobenthic community a precious tool to assess the ecosystem integrity. The benthic organisms generally present a scarse mobility and this increases the probability they may be exposed to stress factors, let them becoming excellent local bioindicators of perturbations, unlike the planktonic and pelagic communities [13], [14], [15], [16].

ISBN: 978-1-61804-224-8

Sediment sampling for soft-bottom macrozoobenthic analyses was performed in the same stations where sediment were collected for chemical and physical analyses.

In each investigated area, surveys were carried out once in the pre-construction phase and once in the final phase of the study. Instead in the monitoring phase, during the laying works, sediments were sampled after each cable installation, with semi-annual campaigns, in order to assess, over time, the possible effects occurring on soft-bottom macrozoobenthic assemblages due to the laying of power lines and the existence of themselves.

Sediments were collected by Van Veen grab or box corer, at the different sampling stations, treated and stored according to definite protocols.

For these reasons, qualitative and quantitative analyses were performed and ecological studies carried out. The systematic recognition of organisms was made at the species level at least for the most representative groups (e.g. Polychaeta, Mollusca, Crustacea, Echinodermata).

C. Sea bottom morphology

The study of the sea bottom morphological characteristics allows to highlight the relationship between natural features and the presence of anthropic structures. This analysis represents an essential tool to study accurately the impact of human activities on the seabed [17], [18]. The acoustic investigations provide the background information necessary for a correct planning of sampling activities and represent the basis for a long-term monitoring study. Furthermore, they permit to monitor sea bottom geomorphological modifications and also to map the sea bottom alterations due to the cables presence.

For the SAPEI monitoring plan, the detailed maps produced by TERNA before the cable laying were used for the positioning of sampling stations and as *ante operam* investigations. The geophysical surveys carried out in the final phase of the monitoring plan, permitted to check the seabed morphology after cable laying and burial. Particular attention was given to sensitive ecosystems such as *Posidonia oceanica* and *Cymodocea nodosa*, in the area in question.

VI. Results and Conclusion

The implementation of the SAPEI monitoring plan, lasted for about 4 years, allowed the collection of a large quantity of environmental data (bottom morphology and bathymetry, surface sediment grain-size, chemistry and ecotoxicology, water column hydrology and nutrients, phanerogams information and characteristics of the macrozoobenthic assemblages).

The activities implemented allowed to discriminate, as far as possible, the alterations attributable to the works from the natural spatial and temporal variability of the environmental indicators used. To this end, the monitoring planning during work execution was adapted to the actual time schedule of construction activities. In the post-construction phase, it was possible to assess the state of the environment following the installation of power lines.

Table II shows the number of collected samples and the number of campaigns carried out during the three investigation phases, the number of linear km surveyed on seagrasses, and the area investigated by geophysical surveys.

Table II. Number of campaigns for each type of survey carried out in the matrices in question. Sampling stations for the environmental components and geophysical investigation area.

Type of survey	Surveys			Samples
	Before	During	After	
Water column				
Hydrological profiles	3	19	3	558
Nutrients	3	11	3	752
Seagrasses				
Quantitative investigation	3	3	1	118
Qualitative investigation	3	17	3	138 km*
Sediments				
Chemistry, physics	3	9	3	151
Biological assays	3	9	3	83
Macrozoobenthos	3	18	3	384
Sea bottom				
Geophysical investigation	0	0	3	13,6 km2**

The environmental data collected during the implementation of the overall Monitoring Plan, allowed to validate the effectiveness of the proposed approach with regard to: i) identification of the appropriate width of the survey area; ii) preparation of the sample design; iii) selection of the parameters to be investigated; iiii) definition of the monitoring frequency. Particular attention was given to sensitive ecosystems (*P. oceanica* meadows and *C. nodosa* praire) which, depending on the project's technical characteristics, may suffer different impact levels.

The creation of a trench in the *P. oceanica* bed with the aim of accommodating pipelines or cables (burial) should be avoided [2], considering the known negative impacts on the meadows (e.g. [19], [20]), while the laying installation (without burial) is an operation that can be carried out without significant interferences on seabed. In the case of healthy prairies the impact might even be reduced to zero, since the meadows tends to cover the cable incorporating it in the *matte*. In this context, it should be noted that, when the fieldworkers pay attention to laying methods and meadow is in good vitality, the sampling effort could be reduced [1].

The environmental monitoring during operations becomes an essential tool to verify the actual effects on sensitive habitats, allowing to intervene quickly and to minimize any possible negative effects. In particular, the case study of SAPEI project allowed us to identify impact degree of the

ISBN: 978-1-61804-224-8

investigated work on surrounding environment and it permitted us to obtain a large amount of data, which will allow to optimize the field and laboratory work in future monitoring plans.

REFERENCES

[1] Bacci T., Rende F.S., Nonnis O., Maggi C., Izzi A., Gabellini M., Massara F., Di Tullio L. (2013) Effects of laying power cables on a Posidonia oceanica (L.) Delile prairie: the study case of Fiume Santo (NW Sardinia, Italy). Journal of Coastal Research, Special Issue No. 65

[2] Boudouresque, C.F., Bernard, G., Bonhomme, P., Charbonnel, E., Diviacco, G., Meinesz, A., Pergent, G., Pergent-Martini, C., Ruitton, S., Tunesi, L., 2008. RAMOGE pub.: 1-202.

[3] ISPRA, Environmental Data Yearbook, 2011

[4] Boudouresque, C. F., Bernard, G., Pergent, G., Shili, A., Verlaque, M., 2009. Regression of Mediterranean seagrasses caused by natural processes and anthropogenic disturbances and stress : a critical review.

[5] Hemminga, M. and C. M., Duarte. 2000. Seagrass Ecology. Cambridge University Press. Bot. Mar. 52, 395-418.

[6] Duarte, C.M. (Eds. 2006), Seagrasses: Biology, Ecology and Conservation. Springer, The Netherlands, pp. 567-593

[7] Ferrat, L., Pergent-Martini C., Roméo, M ., 2003. Assessment of the use of biomarkers in aquatic plants for the evaluation of environmental quality: application to seagrasses. Aquatic Toxicology 65, 187–204.

[8] Montefalcone, M., 2009. Ecosystem health assessment using the Mediterranean seagrass Posidonia oceanica : a review. Ecological Indicators 9, 595 - 604

[9] Pergent-Martini, C., Leoni, V., Pasqualini, V., Ardizzone, G.D., Balestri, E., Bedini, R., Belluscio, A., Belsher, T., Borg, J., Boudouresque, C.F., Boumaza, S., Bouquegneau, J.M., Buia, M.C., Calvo, S., Cebrian, J., Charbonnel, E., Cinelli, F., Cossu, A., Di Maida, G., Dural, B., Francour, P., Gobert, S., Lepoint, G., Meinesz, A., Molenaar, H., Mansour, H.M., Panayotidis, P., Peirano, A., Pergent, G., Piazzi, L., Pirrota, M., Relini, G., Romero, J., Sanchez-Lizaso, J.L., Semroud, R., Shembri, P., Shili, A., Tomasello, A., Velimirov, B., 2005. Descriptors of Posidonia oceanica meadows: use and application. Ecol. Ind. 5, 213-230.

[10] Giraud, G., 1977. Contribution a` la description et a` la phenologie quantitative des herbiers de Posidonia oceanica (L.) Delile. Aix-Marseille II. The`se en Oceanologie, 150p

[11] Pergent, G., 1990. Lepidochronological analysis in the seagrass Posidonia oceanica: a standardized approach. Aquatic. Botany, 37, 39-54.

[12] Pergent, G. and.Pergent-Martini, C., 1991. Leaf renewal cycle and primary production of Posidonia oceanica in the bay of Lacco Ameno (Ischia, Italy) using lepidochronological analysis. Aquatic. Botany. 42, 49-66.

[13] Pearson T.H., Rosenberg R., (1978). Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. Oceanogr. Mar. Biol. Annu. Rev. 16: 229-311.

[14] Montagna P.A. (2005). http://vpr.tamu.edu/antarctic/workshop/files/WP_Montagna.doc

[15] Quintino V., Elliott M., Rodrigues A.M. (2006). The derivation, performance and role of univariate and multivariate indicators of benthic change: case studies at differing spatial scales J. Exp. Biol. Ecol. 330:368-382.

[16] Trabucco B, Penna M., Scardi M., Fresi E. The use of non-taxonomic descriptors to assess the ecological status of soft-bottom macrozoobenthic communities. (2006): 1-7. http://www.ecologia.it/congressi/XVI/articles/.

[17] Kenny, A. J.; Cato, I.; Desprez, M.; Fader, G., Schuttenhelm, R. T. E. and Side, J. (2003) An overview of seabed-mapping technologies in the context of marine habitat classification. ICES J. of Mar. Sci., vol 60, No 2, 411- 418.

[18] Collier, J. S. and Brown, C. J. (2005) Correlation of sidescan backscatter with grain size distribution of surficial seabed sediments. Mar. Geol., vol 214, 431- 449.

[19] Francour, P., Sinnassamy, J.M., Urscheler, F., Fleury, M.C., 1992. Cartographie des fonds et des herbiers à *Posidonia oceanica* entre la presqu'île de Giens et l'île de Porquerolles (Var) pour le passage d'un sea-line. Ville d'Hyères & GIS Posidonie, GIS Posidonie publ., Fr.: 1-72.

[20] Di Carlo, G., Benedetti-Cecchi, L., Badalamenti, F., 2011 Response of *Posidonia oceanica* growth to dredging effects of different magnitude. *Marine Ecology Progress Series*, 423, 39-45.

Consequence of the overexploitation of groundwater sands aquifer of Biskra -South East Algerian-

N. Sedrati, L. Djabri

Abstract—In the area of Biskra, as in so many others Saharan margins, the principal economic activities are related to the date palm cultures and breeding. The importance of palmerais was mainly due to the presence of groundwater and / or phreatic very productive shallow, whose exploitation dated more a century. Though, the recent development in the Ziban region is characterized by expansion, diversification and regularization of economic activities. The water here is the limiting factor in development, and above all farming. The exploitation of groundwater sands of Biskra is an economic imperative, considered a priority; however, increased demand puts an enormous strain about the natural resource.

This results in a lowering of the water of about 20m particularly scared in Biskra city. The region suffers from over-exploitation due to agricultural practice. Examples include the case of the water of the terminal complex, the number of development wells went from 3511en 2000 to 5705 in 2008.

Suitable water management policies are needed to save the very little renewable fossil resource. This management must be based on a proper knowledge and good control of water patrimony, this is how they shall be valued and preserved.

Keywords—Exploitation, lowering, over-exploitation, resource-management

I. Introduction

Biskra region is located in the North Eastern area of the septentrional Sahara and contains many important resources of fossil water. These waters are contained in the various aquifer terminal complex and the continental interlayer.

Recent years an economic expansion, particularly agricultural, took place through the intake of different plans of agricultural development, which resulted in, the one hand, increased water requirements and caused, on the other hand, the hydrostatic equilibrium disturbance aquifers.

An analysis of the current situation of the groundwater sand is very important for the region of Biskra; given the particularly difficult context where interferes agriculture large consumer of water and an arid climate characterized by low precipitation reached an average of 110.55 mm / year calculated at the Biskra station for a period of 34 years [1]. To achieve our objective, we used data from the National Agency for Water Resources of Biskra has performed an inventory of groundwater resources groundwater terminal complex during year 2000 and 2010[2].

The results thus obtained will allow monitoring developments of the different aquifer of the region through time and in space.

.

This work was supported in part by the U.S. Department of Commerce under Grant BS123456 (sponsor and financial support acknowledgment goes here). Paper titles should be written in uppercase and lowercase letters, not all uppercase. Avoid writing long formulas with subscripts in the title; short formulas that identify the elements are fine (e.g., "Nd–Fe–B"). Do not write "(Invited)" in the title. Full names of authors are preferred in the author field, but are not required. Put a space between authors' initials.

F. A. Author is with the National Institute of Standards and Technology, Boulder, CO 80305 USA (corresponding author to provide phone: 303-555-5555; fax: 303-555-5555; e-mail: author@ boulder.nist.gov).

S. B. Author, Jr., was with Rice University, Houston, TX 77005 USA. He is now with the Department of Physics, Colorado State University, Fort Collins, CO 80523 USA (e-mail: author@lamar. colostate.edu).

T. C. Author is with the Electrical Engineering Department, University of Colorado, Boulder, CO 80309 USA, on leave from the National Research Institute for Metals, Tsukuba, Japan (e-mail: author@nrim.go.jp).

II. Part of the Study Area

A. Geography

Biskra region, with its area of approximately 21.671.2 Km2, is part of watershed Chott Melrhir. It is located to the east of the country and south of the Aures. Limited to the North by the province of Batna, to the south by the provinces of Djelfa and El Oued, to the east by the province of Khenchela and to the west by the M'Sila. “Fig.1”

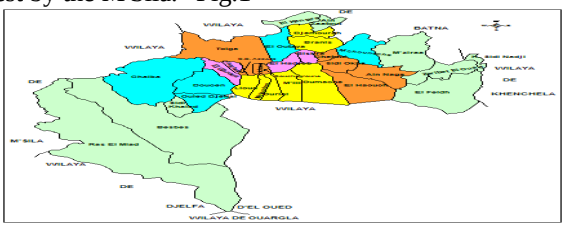


Fig. 1 localization of the study area

The study area has a population of approximately 671,932 inhabitants (2006 census); the high density is localized in larger agglomerations. Covering a utilized agricultural area of 175,335 ha, of which 108,183 ha irrigated [3], the region is subjected to a sizable demand for irrigation water. From the standpoint climate, Biskra is characterized by a climate sharply contrasted to cool winter ranging from December to February

ISBN: 978-1-61804-224-8

and dry summer and warm and very sunny, indeed a very low and irregular annual precipitation reaches about 120mm / year.

B. Geological and Hydrogeological setting

The analysis of the geological environment [4]–[6], revealed that the study area is characterized by its location in a transition zone between formations and structures of the Saharan Atlas and those of the Saharan platform. Inherits the region in general, structure and tectonic atlasic: folds orientation is north east to south west. The passage of alpine formations to plat structures Sahara resulting through a flexure called South Atlasic accident.

The studied aquifer is contained in the sandy clay formations of Miopliocène "Fig.2&3". It consists mainly of an alternation of sands, gravels and clays with a thickness vary entre100 m at the south east the city of Biskra and 200mat the north (El Outaya) Figure 02. She has a transmissivity varying between 4-7 .10-3m^2 / s, the storage coefficient varies from 0.5 to 0.1.

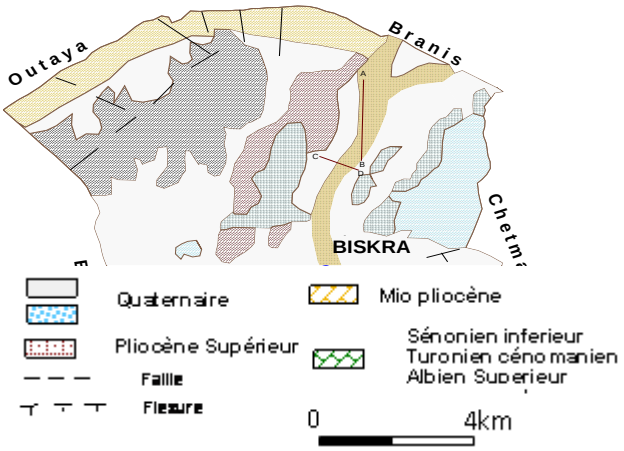


Fig. 2 Hydrogeological map of Biskra, established using the geological map of Biskra, 1979).

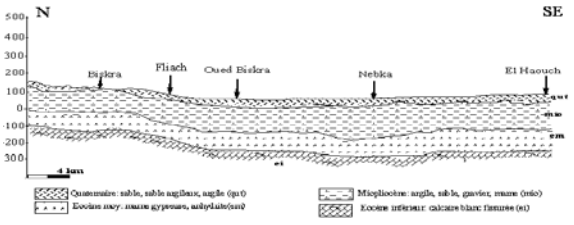


Fig. 3 hydrogeological schematic section of groundwater sands aquifer of Biskra.

III. MATERIALS AND METHODS:

A. The state of exploitation of the groundwater from the sands aquifer of Biskra

a-Year 2000

Volume exploited by drilling: Of the 42 identified drilling 39 exploited (19 drilling for the water supply of the population with a volume of 18 76 hm3/year :18 drilling for irrigation with a volume of 8.20. hm3/year and 02 drilling industry with a volume of 1.1Hm^3/year).

Therefore the total exploited volume of the groundwater from the aquifer sands of Biskra is then estimated to be 26.74 hm3/year a throughput of 895 l / s of which 01 aborted drills and 02 clogged "Fig.4"

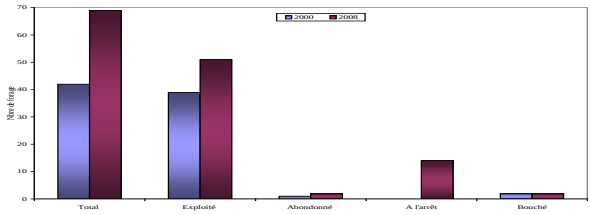


Fig. 4 state piézometric of groundwater drillings capturing the sands aquifer of Biskra.

b-Year 2008:

Volume exploited by drillings: Of the 69 drillings identified, 51 exploited (01Forage for the drinking water supply of the population for a volume of 0,778 hm^3/year and 50 drillings for irrigation purposes for a volume of 5.931Hm^3/ year) .Therefore the total exploited volume from the water sands Biskra is then estimated at 6,708 hm^3, 14 drilling stop, abandoned 02 and 02 clogged "Fig.4"

IV. RESULTS AND DISCUSSION

A. Lowering static level and debits of drilling

From year 2000 through the intake of different plans of agricultural development and the evolute of plasticulture Accordingly a very intense way, a major consumer of water and dam construction fountain gazelles (put service in 2002) with a capacity of 55 Hm^3, resulted in a significant loss of water in the region of Biskra, where the groundwater of sand aquifer was supplied with water coming from the upstream region (El Kantara, Ain Touta and El Outaya).

This situation drives down water reserves, Indeed, reduced the flow rates of drilling "Fig.5", lower static water levels "Fig.6"are very revealing indices of overexploitation.

ISBN: 978-1-61804-224-8

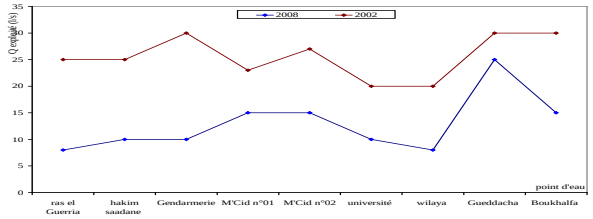


Fig. 5 variation of flow rates of drilling capturing groundwater sands aquifer of Biskra

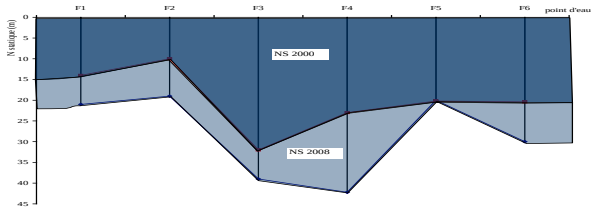


Fig. 6 variation of the static level of a few drillings capturing groundwater sands aquifer of Biskra

B. Impact of overexploitation of water quality of sands groundwater of Biskra

The increased demand for water resources entrained a deterioration of water quality, which has led to an increase in the water salinity and soils Figure 08, impacting significant losses of agricultural land.

The graph "Fig.7"clearly illustrates the variation of dry residue (DR) at the water of the sands of Biskra, a differential variation of the DR is important between the two periods (year 2000 and 2008). This variation is particularly important at the Fliache01 drilling where the value of DR = 2g/l increases of more than 6 g / l.

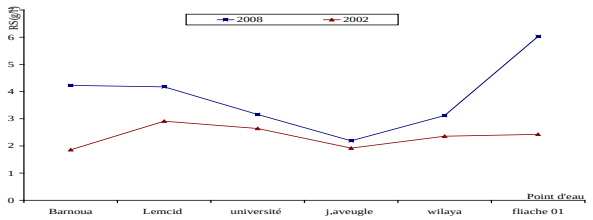


Fig. 7 temporal distribution of the dry residue of the groundwater from the sands aquifer of Biskra.

The variation of the dry residue, follows the conductivity "Fig.8", it would be related to the state of solicitation of the sands groundwater. The number of drillings exploitation increased from 39 in 2000 to 52 in 2008 in an area of 72 km^2. This increase was generated overexploitation of aquifers. Thus the return of irrigation water transiting through the soil contained in gypsiferous formations would have become more charged into salts, causing an increase in the mineralization. Indeed salts contained in the water will percolate into groundwater causing an increase in salinity. Moreover, the present mode of exploitation has generated overexploitation of the resource,
confirmed by the high number of stopping drillings (18 drillings, according to the Agense National of Water Resources, year 2010) and by increasing the depth of the drillings currently capturing the sand aquifer of Biskra.

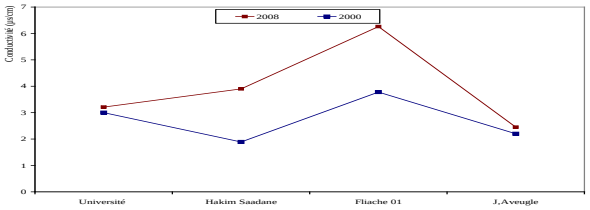


Fig. 8 temporal distribution of the conductivity of the groundwater from the sands aquifer of Biskra.

V. CONCLUSION

This work is a contribution to the determination of the present situation groundwater sands Biskra which face the effects of overexploitation recorded that last decades.
The facts which are the most characteristic the lowering of piezometric levels in this aquifer which can reach + 20 m to the city of Biskra, drying the shallow water table included the drilling and the wells from a large diameter capturing groundwater of Oued Biskra situated upstream from Oued El Hai are totally dried up. This situation is not unique to the region of Biskra but affects other regions of the bottom Algerian Sahara.

REFERENCES

[1] Sedrati.N , Origines et Caractéristiques PhysicoChimiques Des Eaux de la Wilaya de Biskra (Sud Est Algérien). *Thèse de Doctorat 2011.p176.*
[2] ANRH, Inventaire des points d'eau dans la wilaya de Biskra.
[3] DSA , Direction des Services Agricoles de la wilaya de Biskra *2005*
[4] Laffitte R (1939), Etude géologique de l'Aurès. *Thèse, Paris, Bull, Serv. Carte géologique Algérie, Alger.2ème édition.1939. p* 484.
[5] Gouskov .N, Notice explicative de la carte géologique au 1/200 000. Biskra. *Serv. Géol. De l'Algérie. Alger*.
[6] Mauget. G, L'évolution des ressources hydrauliques dans les oasis du bas Sahara algérien. Recherches Sur l'Algérie. *Edition CNRS Paris.* pp 68 – 75.

Environmental micropollutants in livestock products from Susa Valley in Piedmont

R. Desiato, E. Baioni, V. Filipello, G. Cuttica, B. Sparagna, P. Berruto, M. C. Abete, S. Bertolini, C. Maurella, M. Caramelli, L. Chiavacci, G. Ru.

***Abstract*—**Objective: The aim was to describe the contamination due to dioxins and dioxin-like PCBs of cattle dairy and meat products in cattle herds from Susa Valley in Piedmont since the first half of 2000 years. Design: Descriptive study based on a biomonitoring campaign on bovine bulk milk and muscle. Setting and participants: The official samplings have been carried out between 2004 ad 2010: the dataset refers to respectively 99 dairy and 24 muscle samples from 51 cattle herds based in 23 municipalities of the valley. Main outcome measures: Counts and frequencies of samples exceeding either the maximum levels or the action levels set by the European legislation. Results: dl-PCBs showed median concentration values double when compared with dioxins values. More than 60% of both the milk samples and herds exceeded the action levels with the involvement of 10 municipalities most of which nearby a local steel smelter. The dl-PCB values in milk were associated with the distance of each herd from the steel plant. However the temporal trend highlights a clear decrease of the contamination over the 2004-2010 period, when the plant was renewed and the production levels where negatively impacted by the global economical crisis. Conclusion: The findings of the monitoring activity allowed the understanding of the origin and the spatio-temporal evolution of the contamination: this knowledge may be helpful in orienting future controls and the risk mitigation strategies.

***Keywords*—**dioxins, dioxin-like PCBs, environmental contamination, cattle, biomonitoring.

R. Desiato is with the Istituto Zooprofilatttico del Piemonte, Liguria e Valle d'Aosta, Torino, 10154 Italy (corresponding author: +39-011-2686372; fax: +39-011-2686371; e-mail: rosanna.desiato@izsto.it).

E. Baioni is with the Istituto Zooprofilatttico del Piemonte, Liguria e Valle d'Aosta, Torino, 10154 Italy (e-mail: elisa.baioni@izsto.it)

V. Filipello was with the Istituto Zooprofilatttico del Piemonte, Liguria e Valle d'Aosta, Torino, 10154 Italy. She is now with the Department of Veterinary Sciences, University of Turin, Grugliasco, 10095 Italy (e-mail: virginia.filipello@unito.it)

G. Cuttica is with the Department of Vercelli Province of Regional Agency for Environment Protection (ARPA) of Piedmont, Vercelli, 13100 Italy (e-mail: g.cuttica@arpa.piemonte.it)

B. Sparagna is with the Local Health Service (ASL TO3), of Collegno and Pinerolo, Turin, 10093, Italy (e-mail: bruno.sparagna@asl5.piemonte.it)

P. Berruto is with the Local Health Service (ASL TO3), of Collegno and Pinerolo, Turin, 10093, Italy (e-mail: paolo.berruto@asl5.piemonte.it)

M.C. Abete is with the Istituto Zooprofilatttico del Piemonte, Liguria e Valle d'Aosta, Torino, 10154 Italy (e-mail: mariacesarina.abete@izsto.it)

S. Bertolini is with the Istituto Zooprofilatttico del Piemonte, Liguria e Valle d'Aosta, Torino, 10154 Italy (e-mail: silvia.bertolini@izsto.it)

C. Maurella is with the Istituto Zooprofilatttico del Piemonte, Liguria e Valle d'Aosta, Torino, 10154 Italy (e-mail: cristiana.maurella@izsto.it)

M. Caramelli is with the Istituto Zooprofilatttico del Piemonte, Liguria e Valle d'Aosta, Torino, 10154 Italy (e-mail: maria.caramelli@izsto.it)

L. Chiavacci is with the Istituto Zooprofilatttico del Piemonte, Liguria e Valle d'Aosta, Torino, 10154 Italy (e-mail: laura.chiavacci@izsto.it)

G. Ru is with the Istituto Zooprofilatttico del Piemonte, Liguria e Valle d'Aosta, Torino, 10154 Italy (e-mail: giuseppe.ru@izsto.it)

I. Introduction

The term "dioxin" refers to a group of polycyclic aromatic compounds which belong to a family of 210 molecules (congeners) with similar chemical, physical and toxicological properties non intentionally produced by humans. There are 75 congeners of polychlorinated dibenzodioxins (PCDDs) or dioxins and 135 Polychlorinated dibenzofurans (PCDFs) or furans, but only 10 PCDDs congeners and 7 PCDFs congeners are toxicologically significant.

The most toxic is the 2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD) classifies Group I, which means "carcinogenic to humans", by the International Agency for Research on Cancer (IARC) in 1997 (http://monographs.iarc.fr/ENG/Monographs/vol69/volume69.pdf).

Lately the 2,3,4,7,8-Pentachlorodibenzofuran (PeCDF) too has been included in the same group, while the other dioxins and furans congeners have been included in Group 3 or "not classifiable as to carcinogenicity in humans" (http://monographs.iarc.fr/ENG/Monographs/vol100F/mono100F-27.pdf).

Polychlorinated biphenyls (PCBs) are synthetic products allowed for industrial use until 1990s. They are 209 aromatic compounds, 12 of them have the same toxicological significance as dioxins and furans (dioxin-like PCBs or DL-PCBs). In the same IARC update the 126 PCB too has been included in Group 1, while in the main other DL-PCBs have been classified as "probably carcinogenic to humans" (Group 2A).

The environmental damage in a Susa Valley area, in Torino province, became clear after some investigations performed by the Regional Agency for Environment Protection (ARPA) of Piedmont and by the Local Health Service (ASL) in charge. Those surveys begun in 2004 following calls from citizens and majors of 2 municipalities (Bruzolo and San Didero) which were worried by the copious emissions of a steel plant operating locally since 1960s. The productive system analysis done by ARPA Micropollutants Unit confirmed the existence of emissions not adequately captured, while analysis on environmental samples proved the presence of considerable amounts of heavy metals and micropollutants (PCBs, dioxins and furans) [1].

The area, which has a strong local agriculture and animal husbandry sector, it's shaped in a narrow but long alpine valley which extend from the plain near the city of Torino on the East, to the Alps on the West. On its territory there are lots of breeding farms (pig, poultry and cattle): in local cattle farms the diet is almost exclusively based on locally produced fodders. In the area there were 333 cattle farms, nearly half of

ISBN: 978-1-61804-224-8

them were both milk and meat oriented, while the remaining were mostly specialized on meat production rather than dairy. As located in a mountain area, most farm were small to medium size, with less than 30 head of cattle in 60% of cases.

Following the emerging environmental data, the veterinary service of the in charge ASL undertook between December 2004 and February 2005 the first investigations on animal origin food collecting samples of milk and meat from 30 farms located along the entire length of the valley. The monitoring campaign was planned on the basis of available knowledge: the primary way of entering of dioxins and furans in the terrestrial food chain is the atmospheric deposition on vegetables and soil surfaces, subsequently followed by ingestion of fodder and soil slivers by livestock at pasture [2]. Animals stock these compounds in their body fat making them available to human consumption through products like milk and meat [3].

Part of the samples turned out to be contaminated with dioxins and furans above the allowed threshold. Therefore restrictive measures were applied in order to prevent the commercialization of milk and meat yielded by some farms for variable length time spans.

From 2005 to 2007, due to the releasing procedure for Integrated Environmental Authorization (AIA) issued by Torino province, were carried out in the steel plant some interventions in order to enhance smoke capture and the abatement of organic micropollutants in the emissions [1].

The following sampling campaigns conducted between 2007 and 2010 were focused partly on monitoring farms proved to be contaminated but with contamination levels in the productions reverted to legal limits, and partly on verifying the effectiveness of the structural interventions done meanwhile by the steel plant.

During the monitoring period the legislation on dioxins and furans food contamination underwent major modifications in order to cope with other DL-PCBs compounds of comparable dangerousness: until 2006 the European norm (CE Reg. 2375/2001) set a limit for the presence of dioxins and furans in animal origin food; this regulation has been replaced by CE Reg. 199/2006 that introduced for the first time limits for the sum of dioxins, furans and DL-PCBs. Moreover, in 2006 a European Commission Recommendation and another one from the Surveillance Authority EFSA introduced a new principle on the strength of which the authority in charge is in duty of investigating the source of contamination, when in animal origin products are exceeded the “action levels” (lower than norm limits).

Recently allowed limits have been further reduced and limits have been introduced for some non DL-PCBs too (CE Reg. 1259/2011).

The aim of this study is to describe the event of dioxins, furans and DL-PCBs contamination of cattle farms and their food productions that took place in Susa Valley since the first half of 2000s. In particular in this work are described the main episode characteristics, its temporal evolution, its spatial extension and the involved pollutants characteristics.

II. MATERIALS AND METHODS

The data used refer to bulk milk, which means obtained from the whole barn (not from a single head) and individual muscular tissue samples (meat).

In 23 municipalities, along the Valley axis, by the end of 2004 and until 2010, were subjected to sampling on the whole 51 cattle farms with a total of 123 samples (99 milk samples and 24 meat samples).

The monitoring covered initially the entire length of Susa Valley, then were focused gradually over an area considered at higher risk and coincident with the eastern part of the valley.

The analytical investigations were carried out partly by the laboratories of the Institutes for Zooprophylaxis and Research (IIZZSS) of Lazio e Toscana in Rome and of Abruzzo e Molise in Teramo, and partly by the laboratory of the Micropollutants Unit of ARPA Piemonte in Grugliasco (Turin). The analytes were identified, confirmed and quantified using gas chromatography with high resolution mass spectrometry (GC- HRMS) as required by EU Regulation 1883/2006 and following EPA methods 1613 and 1668 [5], [6].

The Regulation calls for the typing of the toxicologically relevant 17 congeners of dioxins and furans and 12 dl-PCBs.

The evolution of legislation meant that the samples have been classified differently along the time according to the limits in force at the time of sampling. For the purposes of this study, were used as reference the values defined by the law in force in the whole 2011 (Regulation 199/2006/CE and Community Recommendations). They are based on the World Health Organization, WHO-TEQ, values of toxic equivalence in turn obtained by multiplying the measured concentration of each congener to the toxic equivalence factors (TEF), which measure the relative affinity of each of them (compared to that of the 2,3,7,8-tetrachlorodibenzo-p-dioxin, 2,3,7,8-TCDD) against the cellular receptor Ah (Aryl hydrocarbon).[4] Despite the TEF values have been the subject revision, based on the indications of the legislation in force during the collection and analysis of samples (EU Regulation 1883/2006), for the purposes of this study were used those defined by the WHO in 1998 [4].

The limit values for the set of dioxins and furans were equal to 3 pg/g of fat for ruminants milk and meat, while for the sum of dioxins, furans and DL-PCBs were respectively 6 pg/g of fat per milk and dairy products and 4.5 pg/g of fat for meat and meat products. The action levels for milk and dairy products were instead equal to 2 pg/g of fat both for dioxins and furans and for DL-PCBs, while for ruminants meat and meat products were respectively 1.5 pg/g of fat for dioxins and furans and 1.0 pg/g of fat for DL-PCBs.

The registry data (e.g. productive orientation for the production of milk or meat, the number of animals per farm, the geographical coordinates of the farm) were obtained through the form accompanying the samples and partly by extraction from the database of the Anagrafe Veterinaria Regionale del Piemonte. The data collected along with the results of analytical investigations have been used for the creation of a database gradually updated over time. For the

data processing we used the software Stata 10.0 (Stata Corp., College Station, TX , USA) and for maps ArcGIS 9.2 (ESRI, Redlands, CA , USA).

Some simple indices such as frequencies, means and medians of the concentrations measured in milk and muscle, useful for the production of charts and maps, were obtained. The geographic coordinates of the farms and steel plant have been used to verify the presence of a gradient of the concentration of micropollutants in bulk milk with distance from the steel plant; the distance was included in a linear regression model using the natural logarithm of the concentration (separately for dioxins and furans and for DL-PCBs) as the dependent variable. The distance was as well in scatter charts. A similar analysis was conducted to describe the temporal evolution: using the same dependent variable, it was evaluated the effect of year of sampling.

III. RESULTS

General Characteristics of the contamination event

In most cases, when the presence of micropollutants was identified, the concentration of DL-PCBs was higher than that observed for dioxins and furans in both milk and meat.

Considering only dioxins and furans, the ratio of dioxins/furans (with an average value of approximately 1:2.2) saw a clear predominance of furans. The first positive samples (exceeding the normative limit) relative to the monitoring carried out between 2004 and 2005, based on the legislation prior to that in force from November 2006 and therefore referred only to the set of dioxins and furans, involved 7 cattle farms (6 milk oriented and 1 meat oriented), from which 11 milk and 4 muscle samples were taken. The farms were located in the municipalities of Almese (1 farm), Bruzolo (3), Condove (1), San Ambrogio (1) , San Didero (1), in the lowest and most eastern part of the Valley.

In light of the limits in force in 2006 and which would take into account the sum with DL-PCBs, samples obtained since 2004 have highlighted a problem of contamination far more extensive: in this case the farms affected by a relevant level of contamination, and then to be subjected to restrictive measures would have been 14 and not 7 (Table I).

Finally, taking into account the criteria based on the most precautionary action levels for dl-PCBs and considering the entire period (2004-2010), the episode actually involved:

(1) 10 municipalities, which are Almese, Avigliana, Borgone, Bruzolo, Condove , Oulx, San Ambrogio, San Antonino, San Didero and Villar Focchiardo;

(2) 61% of the of the farms monitored (31 of 51);

(3) 62% of the milk samples (61 of 99);

(4) 100% of the 24 samples of meat.

Bulk milk contamination

The maximum value observed for dioxins and furans was highlighted in 2005 in a milk oriented farm located in the municipality of San Didero, the TEQ value was 5.2 pg/g of fat, while the lowest value was found in 2006 in a farm located in the town of Rosta, adjointed to the south eastern end of Susa Valley without being part of it.

The distribution of the concentration values of PCDD/F was strongly skewed: only a quarter of the samples exceeded the value of 2.1 pg/g of fat, half of the samples exceeded the value of 1.0, three-quarters of the samples exceeded the value 0.6.

The concentration values of dl-PCBs in milk were higher than those reported for dioxins and furans, as regards both mean and median, the interquartile range and maximum and minimum values.

The maximum value was found in 2007 in a milk oriented farm located, like the highest value of dioxins and furans, in the municipality of San Didero, with a TEQ concentration equal to 26.6 pg/g of fat. The minimum value was found in 2005 in a located in the town of Sauze di Cesana, which is in the south western part of the valley 1500 meters above sea level .

Even for dl-PCBs the distribution of values was strongly skewed: one quarter of the samples exceeded the value of 5.2 pg/g of fat, half of the samples exceeded the value of 2.6, three-quarters of the samples exceeded the value 1.5.

Significantly higher concentrations of dl-PCBs explain why only in a few occasions the contribution of dioxins and furans has been essential to exceed the thresholds defined by the sum of all congeners (Table 1).

Meat contamination

Regarding the concentration values in muscle, all samples originated from the municipalities of Bruzolo (21) and San Didero (3), in which was launched a healthcare restriction for animals destined to slaughtered. For these samples too, the greatest contribution was made by DL-PCBs, the highest value was 136 pg/g of fat reached in an adult cattle slaughtered in 2005; it originated from a meat oriented farm located in the municipality of San Didero.

The distribution of the concentration values of dioxins and furans in muscle samples was as follows: only a quarter of the samples exceeded the value of 2.4 pg/g of fat, half of the samples exceeded the value of 1.6, while three-quarters of the samples exceeded the value of 1.3. The DL-PCB displayed concentration values in meat even higher: one quarter of the samples exceeded the value of 11.4, half of the samples exceeded the value of 7.2, while three-quarters of the samples exceeded the value of 5.3.

Spatial distribution

Since the muscle samples were in a limited number and derived from a territory restricted to the municipalities of Bruzolo and San Didero, was not possible to obtain information about the general contamination of Susa Valley, so the attention was focused for both spatial distribution and temporal trend on the samples of bulk milk.

If we consider the median values of dioxins and furans in milk at single farm level (Fig. 1) over the entire period (2004-2010) is noticeable that the problem is concentrated in the municipalities of Lower Susa Valley and in the town of Oulx (where only one sample was taken). If we consider instead the median values of DL-PCBs, higher concentrations are found only in municipalities in Lower Susa Valley.

ISBN: 978-1-61804-224-8

Scatter diagrams were made in order to verify the existence of a relationship between the concentration of micropollutants in bulk milk and the distance of the sampled farm from the steel plant (Fig. 2). For DL-PCBs, it is clear a concentration gradient with distance (beta= -0.0000617, p< 0.0001, R^2= 0.39): this coincide with a decrease in the concentrations of dl-PCBs in bulk milk of the sampled farms of 5.98% per kilometer of distance from the steel plant. The phenomenon is not as clear in the case of dioxins and furans (beta= 0.0000523, p= 0,643, R^2= 0.002).

The same investigation was conducted separately for the two congeners recently considered carcinogenic (2,3,4,7,8-PeCDF and PCB 126). Consistent with the findings with the TEQ values for dioxins and furans and DL-PCBs, the correlation between the logarithmic values of 2,3,4,7,8-PeCDF and the distance is not significant (beta= -0.0000217 , p= 0.27 R^2= 0.02), while it is in the case of PCB 126 (beta= -0.0000351, p= 0.043, R^2= 0.085) with a reduction of 3.4% per kilometer.

Limiting the regression analysis to the farms located in the 4 municipalities adjacent to the steel plant (San Didero, Bruzolo, Borgone and Villar Focchiardo), there is a significant decrease of concentrations for dioxins and furans too (beta= -0.0001582 , p= 0.007 , R^2= 0.12) with a reduction of 14.6% per kilometer.

Temporal evolution

In milk samples collected over the entire territory of Susa Valley is clear a gradual reduction of the contamination: in particular, the median values of the concentrations of dioxins and furans in milk have been halved, from values of 2 pg/g of fat in 2005 to values below 1 pg/g of fat in 2009; for DL-PCBs, the trend was less regular with an apparent rise in values between 2006 and 2007 (Fig. 3). As evidence of the average trend, the reduction in the concentration of micropollutants is very clear even in the 6 farms located in the 4 municipalities neighboring the steel plant (Borgone, Bruzolo, San Didero and Villar Focchiardo) and in which the sampling was repeated in each of the three main monitoring campaigns carried out by the ASL in the years 2004-2005, 2007, 2009, 2010.

In this case too, for evaluating the temporal trend, a linear regression model has been used, separately for dioxins and furans, for DL-PCBs and for the two carcinogenic congeners (2,3,4,7,8 - PeCDF and PCB 126).

The results showed a significant temporal trend when analyzing logarithmic values of dioxins and furans (beta= -0.279 , p< 0.001 , R^2= 0.36), amounting to an annual reduction of 24.3%, but not for DL-PCBs (beta= -0.0619 , p= 0.212, R^2= 0.016).

Regarding the individual carcinogenic congeners, the applied linear regression model is in both cases significant: for 2,3,4,7,8-PeCDF beta is equal to -0.311 (p<0.001, R^2= 0.33) equal to an annual reduction of 36.5%, for PCB 126 beta is equal to -0.1621 (p= 0.001, R^2= 0.21) equal to a reduction of 15%.

Also when narrowing down the analysis to the four municipalities neighboring the steel plant exists a significant time trend for both dioxins and furans (p<0.001) and for DL-PCBs (p<0.001): the annual decrease of the concentration values of dioxins and furans is equal to 26.2%, while for the dl-PCBs is 22.5%.

IV. DISCUSSION AND CONCLUSIONS

Even with favorable temporal evolution, Susa Valley was the subject to an important episode of contamination that, as regarding cattle, has led to the involvement of most of the farms monitored and their products. It was also found a concentration gradient with the distance from a steel plant located in the valley. In the episode described DL-PCBs contamination prevailed, even though it was always associated with that of dioxins and furans. The contamination event also involved the congeners classified as carcinogenic. Finally, even if the regulatory limits, such as to inhibit the use of food, were exceeded on a few occasions, in most cases, the concentrations found were sufficient to trigger the alarm of health authorities and the need to monitor the evolution of the situation.

Several factors link the contamination observed and the presence of the steel plant. First, the favorable evolution of the episode, with a clear decreasing trend in the concentrations found in a short time span of a few years (in particular for dioxins and furans), seems to be associated with structural interventions that have led to a better conveying of fumes within the plant and a dust abatement through the use of extractor fans and filters. The economic situation seems to have played a certain role too: the global crisis in the past three years caused a reduction in production rates and amount of production.

The spatial analysis seems to confirm the importance of the steel plant emissions, at least for the DL-PCBs and dioxins and furans measured in the 4 communities neighboring the plant.

These results were made possible thanks to a detailed and long-lasting in depth analysis, relatively innovative in Italy , but also by building alliances between the authorities involved (ASL, ARPA, IZS, municipalities, Province, Regional Departments of Health, Environment and Agriculture) and between different professionals (e.g. chemists, physicians, veterinarians, agronomists, epidemiologists). In this specific case the Piedmont Region has established a Technical Committee to promote the exchange of information and strategies to guide strategies of analysis or intervention; within it were identified the main authorities entrusted to risk communication and management.

The strategies adopted were aimed overcome the actual difficulties encountered in the territory when facing contamination events involving dioxins and furans: the analytical process is complex, at present it does not offer the possibility to use screening methods and costs for single analyses are extremely high; consequences for farmers are potentially serious and may result in discontinuation and destruction of productions; economic compensation tools to provide for the damage are currently lacking; it's nearly impossible to carry out reclamation interventions in the areas concerned, and it's difficult as well to identify effective preventive measures (e.g. good practices directed to producers

[7]); and finally, as already said, it's not easy for the authorities, to carry out integrated, or at least coordinated, actions.

In this context, the biomonitoring activities described certainly had the merit of helping to understand the origin and evolution in space and time of the episode of contamination, to identify the critical issues related to this kind of situation and to stimulate the finding of the best intervention strategies.

REFERENCES

[1] Cappa C, Coretti I, Cuttica G, et al. Risk analysis of environmental pollution near a steel plant. Evaluation of health and environmental effects. *Ital J Occup Environ Hyg* 2010; 1: 4-9.

[2] Fries GF. A review of the significance of animal food products as potential pathways of human exposures to dioxins. *J Animal Science* 1995. 73: 1629-50.

[3] Committee on the Implications of Dioxin in the Food Supply, National Research Council *Dioxins and dioxin-like compounds in the food supply. Strategies to decrease exposure.* Washington DC, Institute of medicine of the National Academies, 2003.

[4] Van den Berg M, Birnbaum L, Bosveld ATC, et al. Toxic equivalency factors (TEFs) for PCBs, PCDDs, PCDFs for humans and wildlife. *Environmental Health Perspectives.* 1998; 106: 775-792.

[5] United States Environmental Protection Agency (US EPA), 1994. Method 1613 Revision B. Tetra through octa-chlorinated dioxins and furans by isotope dilution HRGC/HRMS. Disponibile nel sito: http://water.epa.gov/scitech/methods/cwa/organics/dioxins/upload/2007_07_10_methods_method_dioxins_1613.pdf

[6] United States Environmental Protection Agency (US EPA), 1994. Method 1668 Revision A. Chlorinated biphenyl congeners in water, soil, sediment, and tissue by HRGC/HRMS. Disponibile nel sito: http://nepis.epa.gov

[7] Dioxins and PCB pollution prevention at farm. Good practices of preventive veterinary medicine. Available at: http://www.regione.piemonte.it/sanita/cms/animali/allevamenti/968-manuali-di-buone-pratiche-di-allevamento.html

Table I. Crude number of sample and companies (and their percentage values in brackets) in which concentration values where above thresholds allowed by CE Reg. 199/2006 (time period 2004-2010).

	Milk samples n°	Meat samples n°	Farms n°
dioxins and furans (3 pg/g)	11 (11,1%)	4 (16,7%)	7 (13,7%)
dioxins, furans and DL-PCBs (6pg/g milk, 4.5 pg/g meat)	22 (22,2%)	21 (87,5%)	14 (27,5%)

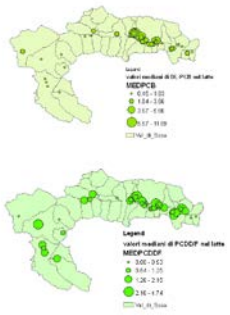


Figure 1. Spatial distribution of median values of concentration of DL-PCBs (above) and dioxins and furans (below) in milk of the 51 monitored farms evaluating sampling location.

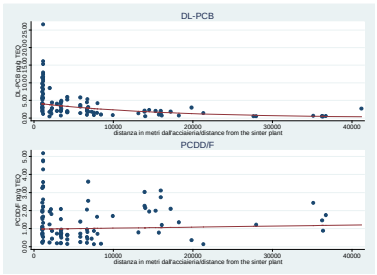


Figure 2. Scatter Plot of observed concentration values respectively for DL-PCBs (above) and for dioxins and furans (under) in 99 samples of milk of 51 monitored farms compared with the distance in meters of steel plant. A regression curve has been fitted on logarithmic concentration values.

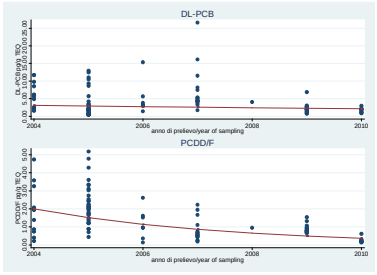


Figure 3. Scatter Plot of observed concentration values respectively for DL-PCBs (above) and for dioxins and furans (under) in 99 samples of milk from the 51 monitored farms by year of sampling. A regression curve has been fitted on logarithmic concentration values.

ISBN: 978-1-61804-224-8

Life cycle external cost of green electricity: The case of Greek power plants

Dimitrios A. Georgakellos, Eleni A. Didaskalou

***Abstract*—** The aim of the present work is to estimate and compare the air pollutants externalities associated with the life cycle of renewable energy sources power plants. This is being realized by applying the NEEDS framework to quantify the external cost as well as the basic principles of the Life Cycle Assessment (LCA) methodology. The examined external cost has been calculated for five types of power plants (biomass-fired, hydro, photovoltaic, wind and geothermal ones). The general limitation of the external cost methodology applies to this work. Similarly, the data limitations as well as the assumptions related to the LCA framework may affect the results.

***Keywords*—**Air pollution, external cost, life cycle assessment, renewable energy sources.

I. Introduction

The European energy policy has led to common rules throughout Europe and a pooling of Europe's efforts to secure the energy that it needs at an affordable price, while generating the least possible pollution [1]. In percentage terms energy supply accounted for 30% of the Union's total emissions in 2011 [2]. As carbon dioxide concentrations globally have increased by 40% since pre-industrial times, primarily from fossil fuel emissions [3] an appropriate understanding of the GHG emission characteristics of various power generation systems from an environmental perspective is required [4].

It must be noted that climate change can also have direct effects on energy endowment, infrastructure, and transportation and indirect effects through other economic sectors [5]. In conclusion a high penetration of renewable energy beyond 2020 is a pre-requisite for a secure, zero-carbon energy system [6]. The use of renewable electricity in European Union in 2010 was 641.7 TWh of which 333.7 TWh from hydro power, 155.1 TWh from wind power followed by biomass (123.6 TWh), solar (23.2 TWh), geothermal (5.6 TWh) and marine (0.5 TWh) [7].

The present work attempts to investigate the air pollutants externalities associated with the energy generation from renewable energy sources (RES), making a comparison among them. However, when comparing environmental issues of different options fulfilling a similar function, it is important to consider the complete life cycle and not only one phase, e.g. production or use. This is because environmental impacts and benefits may occur at different phases of the life cycle.

D. A. Georgakellos is Professor at University of Piraeus, Department of Business Administrator, 80, Karaoli & Dimitriou St. 185 34 Piraeus, GREECE (phone: +30 210 414 2252; fax: +30 210 414 2339; e-mail: dgeorg@unipi.gr).

E. A. Didaskalou., is with University of Piraeus, Department of Business Administrator (e-mail: edidask@unipi.gr).

II. Life Cycle Assessment of Power Generation Systems

Life Cycle Assessment is a useful tool for sustainable decision making as it helps quantifying and comparing the environmental impacts of providing goods and services due to the increasingly interested of general public in the environmental quality of products and production processes [8]-[9]-[10]. The prime purpose of LCA, is to support the choice of different (technological) options for fulfilling a certain function by compiling and evaluating the environmental consequences of these options [11].

During the evolution of LCA, a number of related applications emerged and this variation is also reflected in the level of sophistication and to some extent also in the choice of methodology [12]. LCA provides a consistent basis for comparisons between alternatives based on the environmental consequences associated with them, however it is fundamental to apply the life cycle vision and take into account both the economic and environmental costs when identifying the most eco-efficient technology [13]-[14]. However, results from an LCA can mainly be used for identification of parts and aspects of a life cycle where improvements in the environmental performance are important [15].

The philosophy adopted by LCA is that the true extent of the environmental burden can only be understood if all steps in the delivery, use, and eventual disposal of the product or service are accounted for in the final analysis. As a consequence ISO has sponsored the development of a series of international standards to describe a consistent methodology. The ISO 14040 series of standards, which is part of the ISO 14000 series on environmental management, is the result. The umbrella standard is ISO 14040 *Life Cycle Assessment-Principles and Framework*. It summarizes the aim of LCA in the following way: LCA is a technique for assessing the environmental aspects and potential impacts associated with a product, by compiling an inventory of relevant inputs and outputs of a product system; evaluating the potential

environmental impacts associated with those inputs and outputs and interpreting the results [16]

In this context, the LCA methodology is described by four phases: (1) goal and scope definitions; (2) inventory analysis; (3) impact assessment; and (4) interpretation [17]-[18]. The foundation of a product LCA is the inventory component, where energy, raw materials and environmental releases are measured [19]-[20]. Specifically, the task in the Inventory stage is to trace (ideally) all inputs to and outputs from every stage in the life cycle back to the associated terminal inputs from and outputs to nature (the environment). The flows may usefully be segregated into inputs of materials and outputs of wastes to air, land and water. In practice, it may not be possible to follow all of the input flows all the way back to the extraction of resources from the environment, but where this is so it must be acknowledged in the study report and the consequences (for the use of the report) should be assessed [21].

In the present work, the life cycle inventory concept is being used in order to quantify the atmospheric emissions associated with each RES power generation technology under examination (biomass-fired, hydro, photovoltaic, wind and geothermal). In the power sector, the assessment should include extraction, processing and transportation of fuels, building of power plants, production of electricity and waste disposal [22].

III. External Cost of Power Generation Systems

The external costs of energy are the costs not reflected in the market price, well over 100% for some energy sources [23]. Comparative information on health and environmental impacts of various energy systems can assist in the evaluation of energy options [24]. In order to appraise the environmental impacts of various electricity production technologies, one of the most widely accepted approach today relies on external costs i.e. monetary value of damages caused by electricity production. External costs are imposed on society (e.g. human health) and the environment (e.g. built environment, crops, forests and ecosystems) and are not accounted for by the producers or the consumers of electricity [25]. Estimates of future economic damages resulting from atmospheric pollution have an important impact on policy decisions being made today. Reducing airborne emissions and protecting ourselves from those impacts will be costly, but a failure to act to address these impacts would be even more expensive [26].

Several authors have attempted to publish estimates of annual climate change damages. Most of the estimates are comprehensive because they address market and non-market impacts. Such a comprehensive estimate concerning the United States estimates that in 2012, the federal government spent $96 billion to clean up the disastrous effects of climate disruption [27]. Regarding Europe existing socio−economic vulnerabilities may be exacerbated by the impacts of climate change. Significant reductions in damage costs can be achieved by global and European mitigation policies, consistent with the UNFCCC 2 °C objective, in combination with adaptation actions [28].

IV. Estimation of LCA External Cost of RES Power Plants

Electricity is a key factor for economic and social development. However, the power generation has significant environmental impacts. The most important being human health impact (both, increased mortality in term of reduction of life expectancy as well as increased morbidity, i.e. cardiovascular and pulmonary problems, due to long or short-term exposure) caused by air pollutants (particulate matter, nitrogen oxides, sulphur dioxide, etc) formed during the normal plant operation [29]. However, impacts from the whole life cycle of electricity supply and not only the operation of a power plant should also be adequately taken into account [30]. A practice for evaluating the environmental impacts of the energy sector is the impact pathway methodology developed in the ExternE project funded by the European Commission. The impact pathway analysis aims at modelling the causal chain of interactions from the emission of a pollutant through transport and chemical conversion in the atmosphere to the impacts on various receptors, such as human beings, crops, building materials or ecosystems. Welfare losses resulting from these impacts are transferred into monetary values based on the concepts of welfare economics [31]-[32]. The impact pathway methodology is a bottom-up approach, on which is usually based the estimation of marginal costs [33].

The impacts covered by the methods used for external cost assessment within NEEDS (a project using ExternE methodology) are Human Health, Loss of Biodiversity, Crop Yield and Material Damage. Regarding Climate Change, estimates of the damage costs of greenhouse gas emissions differ not only because the underlying integrated assessment models represent key climate and socio-economic relations differently, but also because there are a number of assumptions to be made to which these estimates are highly sensitive, which cannot easily be resolved [32]-[34]. The unit damage costs used for quantifying externalities from airborne pollutants and GHG are summarised in Table I [32].

Table I contains the various pollutants and CO_2 life cycle emission factors, of the five power generation technologies examined here (biomass-fired, hydro, photovoltaic, wind and geothermal). The construction and operation in each stage were examined, while the decommissioning in each stage was excluded. Subsequently Table II includes LCA atmospheric emission factors concerning the best currently available technology of various electricity generation plants, reported in the literature [13]-[32]-[35]-[41]. However, regarding the hydro power plant these data refer to the present-day technology of actual plants in Greece because these technologies are strongly site-specific. Particularly, the LCA airborne pollutants of the hydro power plant have been estimated based on direct relevant information given by PPC Renewables SA (the subsidiary for renewables of Public Power Corporation - PPC, the major electricity producer in

Greece). The information concerns a local hydropower plant (2x85MW) with dam. Specifically, during its construction it has been used:

- 153,200 m^3 of concrete,
- 8,800,000 m^3 of clay, sand and gravel, aggregates etc,
- 1,775,000 kg of steel,
- 11,892,568.2 litres of diesel.

The average annual production of energy is about 320 GWh/y, while its lifespan is 100 years approximately. For the calculation of the emission factors it has been considered the following: the LCA NMVOC (non-methane volatile organic compounds), NOx, and PM emission factors of concrete for Greece are 0.0028, 0.0105, 0.0009 kg /m3 respectively [35]; the LCA NMVOC, NOx, PM and SO2 emission factors of steel (hot rolled coil) are 0.00072, 0.0078, 0.00372 and 0.0052 kg /kg respectively [36]-[37]; the combustion of 1 litre of diesel fuel produces around 0.003, 0.0623, 0.0003 and 0.0015 kg of NMVOC, NOx, PM and SO2 respectively [38]; the LCA SO2 emission factor of aggregates is 1.48x10-5 kg/kg, which has been calculated considering that the bulk density of sand and gravel is 1300-2000 kg/m3 and of clay at mine is 2000 kg/m3 [39]-[40]. Regarding the CO2 LCA emission factor of the hydro power plant, it refers to the same plant, as it has been reported in the literature [13].

Finally, external costs are calculated by multiplying the relevant life cycle inventory data presented in Table II with the unit damage costs derived from the Table I. The results are shown in Table 3, given per impact type (human health, loss of biodiversity, crop yield, material damage and climate change). It should be noted, however, that taking into account the overall uncertainties related to both the quantification of external costs as well as to the life cycle specification of different electricity generation technology configurations, the data of Table III provides rather external cost estimates for typical average configurations than detailed external cost information, and thus they indicate the order of magnitude of externalities from the electricity generation technologies examined here.

V. Discussion and Conclusions

In order to better understand the outcome of our analysis, a radar presentation is used in Fig. 1 to 5. In this chart type, each impact category (health, biodiversity, crop yield, material damage and climate change) has its own value axis radiating from centre point. The problem is that each of these axes should have different scale. Thus, each impact category (e.g. health, biodiversity etc.) has its own axis scaled from 0 to 1 (for better displaying the results, in hydro and wind figures, the scale of the diagram has been adapted from 0 to 0.1). Lines connect all the values forming a polygon (the LCA polygon). In general, a radar diagram compares the aggregate value of a number of data series. Therefore, it is evident that the RES type that covers the most area represents the worst environmental performance

Table I. Unit damage costs for air pollutants per impact category

Pollutant	Unit	Impact				
		health	biodiversity	crop yield	material damage	climate change
NMVOC	€/t	941	-70	189	0	0
NOx	€/t	5,722	942	328	71	0
PPM (2.5-10 μm)	€/t	1,327	0	0	0	0
PPM (< 2.5 μm)	€/t	24,570	0	0	0	0
SO_2	€/t	6,348	184	-38	259	0
CO_2	€/t	0	0	0	0	7

Table II Life cycle air pollutants emission factors of various RES power plants

Pollutant	Unit	RES Type				
		Biomass [a]	Hydro [b]	PV [a]	Wind [c]	Geothermal [d]
NMVOC	kg/kWh	2.22E-04	1.17E-06	7.09E-05	8.05E-06	0.00E+00
NOx	kg/kWh	1.76E-03	2.36E-05	1.36E-04	3.86E-05	2.00E-05
PPM (2.5-10 μm)	kg/kWh	4.86E-05	3.22E-07	4.73E-05	1.17E-05	1.00E-05
PPM (< 2.5 μm)	kg/kWh	4.25E-05	0.00E+00	2.37E-05	0.00E+00	0.00E+00
SO_2	kg/kWh	5.31E-04	8.99E-06	2.33E-04	3.83E-05	2.71E-03
CO_2	kg/kWh	1.80E-02	2.51E-03	5.52E-02	9.56E-03	1.31E-01

ISBN: 978-1-61804-224-8

Table III. Life cycle air pollutants emission factors of various RES power plants

RES Type	Unit	Impact type					Total
		Health	Biodiversity	Crop Yield	Material Damage	Climate Change	
Biomass	€/kWh	1.48E-02	1.74E-03	5.99E-04	2.62E-04	1.26E-04	**1.75E-02**
Hydro	€/kWh	1.94E-04	2.38E-05	7.62E-06	4.00E-06	1.76E-05	**2.47E-04**
PV	€/kWh	2.97E-03	1.66E-04	4.92E-05	7.00E-05	3.86E-04	**3.64E-03**
Wind	€/kWh	4.87E-04	4.28E-05	1.27E-05	1.27E-05	6.69E-05	**6.22E-04**
Geothermal	€/kWh	1.73E-02	5.17E-04	-9.64E-05	7.03E-04	9.14E-04	**1.94E-02**

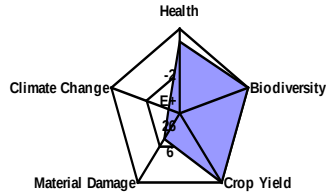


Fig. 1 LCA polygon of a biomass-fired power plant

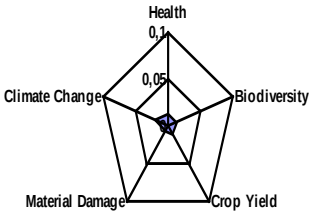


Fig. 2 LCA polygon of a hydro power plant

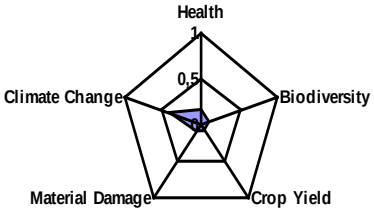


Fig. 3 LCA polygon of a photovoltaic installation

Consequently, a first remark that could be done is that, in spite that the analysis concern RES technologies, it does exist external cost (even if it is almost negligible in some cases) associated with their life cycle. Specifically, this cost seems to be higher for biomass-fired and geothermal power plants, much lower for photovoltaic installations and practically insignificant for hydro and wind power plants. Regarding the impact categories, the biomass-fired power plants affect mainly the biodiversity, the crop yield and the health of people, while the geothermal power plants have damages on health, climate and materials. The impacts of hydro, wind and photovoltaic installations are less important and concern principally the climate change issue.

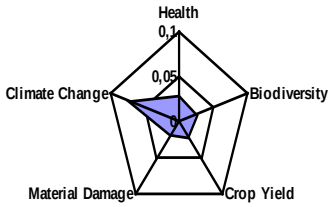


Fig. 4 LCA polygon of a wind power plant

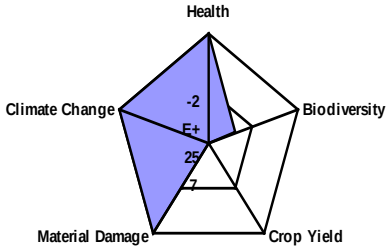


Fig. 5 LCA polygon of a geothermal power plant

Finally it must be mentioned that even though LCA is a powerful tool to assess the environmental impacts of products/services, some important limitations have been identified in recent years. The main limitations are related to the LCA methodological approach, especially data quality and collection, definition of the system, time boundaries, and process modelling. However, the estimation of external costs is important for decision makers in the electricity sector to develop strategies for emission reduction and to develop environmental and energy policies

REFERENCES

[1] *The European Union explained: Energy*, European Commission, 2012. Available: http://europa.eu/pol/ener/index_en.htm

[2] *Report from the Commission to the European Parliament and the Council: Progress towards achieving the Kyoto and EU 2020 objectives*, European Commission, 2013. Available : http://ec.europa.eu/clima/policies/g-gas/docs/com_2013_698_en.pdf

[3] *Climate Change 2013: The Physical Science Basis*, IPCC, 2013. Available: http://www.climate2013.org/images/uploads/WGI_AR5_SPM_brochure.pdf

[4] H. Hondo, "Life cycle GHG emission analysis of power generation systems: Japanese case," *Energy*, vol. 30, no. 11-12, pp. 2042-2056, August–September 2005.

[5] *Climate impacts on energy systems*, The World Bank, 2011. Available: https://openknowledge.worldbank.org/handle/10986/2271

[6] *Hat-trick 2030*, European Renewable Energy Council, 2013. Available: http://www.erec.org/fileadmin/erec_docs/Documents/Publications/EREC_Hat-trick2030_April2013.pdf

[7] Snapshots of renewable energy developments in the European Union, Joint Research Center, 2013. Available: http://iet.jrc.ec.europa.eu/remea/sites/remea/files/reqno_jrc85377_snapshots_res_final_print.pdf

[8] H. Jeswani, A. Azapagic, P. Schepelmann and M.Ritthoff, "Options for broadening and deepening the LCA approaches," Journal of Cleaner Production, vol. 18, no. 2, pp. 120-127, January 2010.

[9] G. Rebitzera, T. Ekvallb, R. Frischknechtc, D. Hunkelerd, G. Norrise, T. Rydbergf,, W.-P. Schmidtg, S. Suhh, B.P. Weidemai and D.W. Penningtonf, "Life cycle assessment. Part 1: Framework, goal and scope definition, inventory analysis, and applications," *Environment International*, vol. 30, no. 5, pp. 701– 720, July 2004.

[10] D. Huybrechts, R. Berloznik, G. Wouters, J.-Y. Marion, G. Valenduc and P. Vendramin, "The role of ecobalances in environmental decision-making," *Journal of Cleaner Production*, vol. 4, no. 2, pp 111-119, 1996.

[11] J. Guinée, G. Huppes, R. Heijungs, "Developing an LCA guide for decision support,". *Environmental Management and Health*, vol. 10, no. 3, pp. 301-311, 2001.

[12] *Life Cycle Assessment (LCA): A guide to approaches, experiences and information sources*, European Environmental Agency, Environmental Issues Series, no 6, 1997, Available: http://www.eea.europa.eu/publications/GH-07-97-595-EN-C/Issue-report-No-6.pdf/view

[13] D. Georgakellos, "Climate change external cost appraisal of electricity generation systems from a life cycle perspective: The case of Greece," *Journal of Cleaner Production*, vol. 32, no. , pp. 124-140, September 2012.

[14] I. Bribián, A. Capilla, A. Usón, "Life cycle assessment of building materials: Comparative analysis of energy and environmental impacts and evaluation of the eco-efficiency improvement potential," *Building and Environment*, vol. 46, no. 5, pp. 1133-1140, May 2011.

[15] T. Graedel, B. Allenby, *Industrial Ecology and Sustainable Engineering*, Pearson: Upper Saddle River, NJ, USA, 2010.

[16] S. Ross, D. Evans, "Use of Life Cycle Assessment in environmental management,". *Environmental Management*, vol. 29, no. 1, pp. 132-142 January 2002.

[17] D. Georgakellos, "The use of the LCA polygon framework in, waste management," *Management of Environmental Quality: An International Journal*, vol. 17, no. 4, pp 490-507, 2006

[18] *Life cycle assessment: principles and practice*, EPA/600/R-06/060, U.S. Environmental Protection Agency: Cincinnati, USA, 2006. Available: http://www.epa.gov/nrmrl/std/lca/lca.html

[19] O. Hassan, "A value-focused thinking approach for environmental management of buildings construction," *Journal of Environmental Assessment Policy and Management*, vol. 5, no. 3, pp. 247-261, June 2003.

[20] E, Ison and A. Miller,, "The use of LCA to introduce life-cycle thinking into decision-making for the purchase of medical devices in the NHS," *Journal of Environmental Assessment Policy and Management*, vol. 2, no.4, pp. 453-476, December 2000.

[21] D. Georgakellos, "Evaluation of life cycle inventory results using critical volume aggregation and polygon-based interpretation," *Journal of Cleaner Production*, vol. 13, no. 6, pp. 567-582, May 2005.

[22] R. Dones, U. Gantner and S. Hirschberg, "Greenhouse gas total emissions from current and future electricity and heat supply systems," in *Proceedings of 4th International Conference on Greenhouse Gas Control, Technologies (GHGT-4)*, B. Eliasson, P. Riemer, and A. Wokaun, Ed. Amsterdam: Pergamon, 1999, pp. 891-896.

[23] Health and Environmental Impacts of Electricity Generation Systems: Procedures for Comparative Assessment, Technical reports series no. 394, International Atomic Energy Agency, Vienna, 1999.

[24] R., Montanari, "Environmental efficiency analysis for ENEL thermo-power plants," *Journal of Cleaner Production*, vol. 12, no. 4, pp. 403-414, May 2004 2004.

[25] F. Ackerman, A. Stanton, "The Cost of Climate Change - What we'll pay if Global Warming continues unchecked," Natural Resources Defence Council: New York, USA, 2008. Available: http://www.nrdc.org/globalwarming/cost/cost.pdf

[26] D. Lashof, A. Stevenson, "Who Pays for Climate Change?,", NRDC Issue paper, May 2013. Available: http://www.nrdc.org/globalwarming/files/taxpayer-climate-costs-IP.pdf

[27] *Climate change, impacts and vulnerability in Europe 2012*, EEA Report No 12, Nov 2012. Available: http://www.eea.europa.eu/publications/climate-impacts-and-vulnerability-2012

[28] D. Hall, "External Costs of Energy," in *Encyclopedia of Energy*, vol. 2, C. Cleveland, Ed. Elsevier , 2004, pp. 651-667.

[29] A. Hainoun, A. Almoustafa, M. Seif Aldin, "Estimating the health damage costs of syrian electricity generation system using impact pathway approach," *Energy*, vol. 35, no. 2, pp. 628–638, February 2010.

[30] *CASES: Cost Assessment of Sustainable Energy Systems*, Project co-funded by the European Commission within the Sixth Framework Programme, Deliverable No D.13.5, November 2008. Available: http://www.feem-project.net/cases/documents/deliverables/D_13_5%20participation%20report.pdf

[31] *ExternE, Externalities of Energy*, A research project of the European Commission. Available: http://www.externe.info/externe_2006/

[32] *External costs from emerging electricity generation technologies*, Deliverable n° 6.1 – RS1a NEEDS Project, March 2009. Available: http://www.needs-project.org/docs/RS1a%20D6_1%20External%20costs%20of%20reference%20technologies%2024032009.pdf

[33] *Handbook on estimation of external costs in the transport sector*, European Commission DG TREN, February 2008, Availlable: http://ec.europa.eu/transport/themes/sustainable/doc/2008_costs_handbook.pdf

[34] *NEEDS: New Energy Externalities Developments for Sustainability*, Project co-funded by the European Commission within the Sixth Framework Programme. Available: http://www.needs-project.org/

[35] A. Biska, N. Oikonomou, "Environmental Consideration of Ready-Mixed Concrete Production," *Tech. Chron. Sci. J.* TCG , I, vol. 26, no. 3, pp. 35-48, September-October 2006.

[36] *Life cycle inventories of energy systems: Results for current systems in Switzerland and other UCTE countries*, Data v2.0 Ecoinvent report No. 5, Ecoinvent centre, Swiss Centre for Life Cycle Inventories, Dec 2007. Available: http://ukshedstores.com/documents/documents_in_english/Life-cycle-analysis-PSI-05.pdf

[37] *Methodology report: Life cycle inventory study for steel products* World Steel Association 2011. Available: http://www.worldsteel.org/dms/internetDocumentList/bookshop/LCA-Methodology-Report/document/LCA%20Methodology%20Report.pdf

[38] *The Environmental Footprint of Surface Freight Transportation*, Transportation Research Board Special Report 291, Lawson Economics Research, Inc Ottawa, Canada, June 2007. Available: http://onlinepubs.trb.org/onlinepubs/sr/sr291_lawson.pdf

[39] D. Kellenberger, H.-J.Althaus, N. Jungbluth N. and T.Künniger, "Life Cycle Inventories of Building Products," Final report ecoinvent data v2.0 No. 7. Swiss Centre for Life Cycle Inventories, 2007. Available: http://www.ecoinvent.org/support/old-doc/rep/reports-for-guests-users/

[40] Life Cycle Assessment of Aggregates, EVA025 –Final Report: Aggregates Industry Life Cycle Assessment Model: Modelling Tools and Case Studies, Waste and Resources Action Programme, August 2009. Available: http://www2.wrap.org.uk/downloads/EVA025-MIRO_Life_Cycle_Assessment_of_Aggregates_final_report.16573fdf.8879.pdf

[41] *Life Cycle Analysis of GHG and Air Pollutant Emissions from Renewable and Conventional Electricity, Heating, and Transport Fuel Options in the EU until 2030*, ETC/ACC Technical Paper 2009/18, Available: http://acm.eionet.europa.eu/reports/docs//ETCACC_TP_2009_18_LCA_GHG_AE_2013-2030.pdf

The effectiveness of electrocoagulation in wastewater treatment

Demetra Tsigalou, Maria Psaroudi, Christos Tourikas and Efthymios Lytras

***Abstract*—** Athens Water and Sewerage Company (EYDAP) is responsible for water and wastewater treatment and the respective networks of Athens, the capital of Greece. EYDAP treats more than 1.000.000 m^3 of water and more than 700.000 m^3 of wastewater daily by operating four water and three wastewater treatment plants. EYDAP uses the classic biological treatment process for wastewater but is also seeking new innovative methods to compliment and develop the existing procedures towards more effective and cost saving solutions. Electrocoagulation is a technology that removes components from wastewater by applying a strong electric field which produces a series of oxidation and reduction reactions. EYDAP's R&D department performed an extended test of the electrocoagulation process to a large range of different wastewater matrices in bench scale experiments.

The results of this work show that electrocoagulation proves to be a relatively effective method in wastewater treatment. In the total of the samples tested including all matrices, the decrease of the concentration of all parameters was more than 50% excluding total nitrogen (TN) and ammonium (NH_4^+). In the samples from domestic and septic tanks wastewater there has been a significant decrease of total phosphorus and oil and grease as well as COD, BOD and phenols. A decrease of the concentration of surfactants is also recorded but not of total nitrogen and ammonium. In leachates samples and in samples from chemical toilets the decrease of the concentration of the tested compounds was moderate. Samples from olive oil industry effluents showed remarkable decrease of the concentrations of all compounds tested and especially COD, phenols and surfactants. Metals concentrations in leachates had a remarkable decrease which was high in the case of the very toxic Hg while in the samples from chemical toilets the decrease of metals concentration was average. In the samples from septic tanks the decrease of Al concentration was high.

In order to examine the efficiency of electrocoagulation in wastewater disinfection, samples have been tested for total coliforms, fecal coliforms and *E.Coli*. After electrocoagulation, complete absence of the above microorganisms was recorded, demonstrating thus that electrocoagulation provides full disinfection in wastewater samples.

***Keywords*—**disinfection electrocoagulation wastewater treatment.

I. Introduction

ATHENS Water and Sewerage Company (EYDAP) is responsible for water and wastewater treatment and management of the respective distribution networks of Athens, the capital of Greece. EYDAP treats more than 1.000.000 m^3 of water and more than 700.000 m^3 of wastewater daily. EYDAP operates three Wastewater Treatment Plants (WWTP) and one of them receives also wastewater from septic tanks and biodegradable wastewater carried by trucks in addition to domestic wastewater from the wastewater network. All three EYDAP's WWTPs operate using the classic biological treatment process. However, the evolution of technology dictates the assessment of new types of processes that are more stable than the biological reactors and may reduce energy consumption and the production of large quantities of sludge. Considering the above, EYDAP's R&D department performed an extended test of the electrocoagulation process to a large range of different wastewater matrices in bench scale experiments.

Demetra Tsigalou, Dr. Maria Psaroudi and Christos Tourikas work in the R&D dept. of Athens Water and Sewerage Company (EYDAP), Oropou 156, Athens, Greece.

Dr. Efthymios Lytras is the Deputy Director of Quality and R&D, Athens Water and Sewerage Company (EYDAP), Oropou 156, Athens, Greece, tel +30-210-2143273, fax +30-210-2143293, email: lytras@eydap.gr

II. Electrocoagulation technology

Electrocoagulation is a technology that removes components from wastewater by applying a strong electric field that produces a series of oxidation and reduction reactions. By decomposing the electrodes, the metallic ions produced are subject to fast hydrolysis and the products of the hydrolysis neutralize the charge of the suspended particles driving them to a fast coagulation and sedimentation [1], [3]-[5]. Electrodes consist of iron and aluminum have special coagulation properties [5],[6] and are very efficient in decoloring industrial wastewater [7].

III. Materials and methods

In this work a large range of wastewater matrices has been tested in order to quantitate the efficiency of electrocoagulation. The main targets were to test if electrocoagulation can eliminate the concentration of various components in wastewater, perform disinfection without the use of additional disinfectants such as sodium hypochlorite and produce effluent suitable for reuse.

A bench scale electrocoagulation device with a capacity of treating 2 liters of wastewater per minute has been used. All tests have been carried in the accredited R&D laboratory of EYDAP.

Almost 500 tests have been carried over as it is shown in the following Table I:

Table I: Number of tests per parameter

COD	65	Color	25
BOD	53	Oil and Grease	18
TP	57	Suspended Solids	5
TN	56	Total Coliforms	15
NH_4^+	51	Fecal Coliforms	15

ISBN: 978-1-61804-224-8

Phenols	57	E.Coli	15
Surfactants	57	Metals	12
Total			501

IV. RESULTS AND DISCUSSION

Electrocoagulation proves to be a relatively effective method in wastewater treatment. In the total of the samples tested including all matrices, the reduction of the concentration of all compounds was more than 50% excluding total nitrogen (TN) and ammonium (NH_4^+).

In the samples of domestic and septic tanks wastewater, there has been a significant reduction of total phosphorus and oil and grease (85-90%) as well as COD, BOD and phenols (60-73%). A decrease of the concentration of surfactants is also monitored (56-63%) but not of total nitrogen and ammonium. The negative effect in total nitrogen and ammonium concentrations is due to chemical reactions that take place during the process. Proteins and other macromolecules that contain nitrogen prove to not be removed efficiently by the electrocoagulation process. In addition, since dissolved ammonium (NH_4^+) in wastewater is removed mostly by forming insoluble compounds as struvite ($NH_4MgPO_4 \cdot 6(H_2O)$), lack of phosphorus or magnesium in the raw wastewater may cause insufficient removal of ammonium.
EYDAP's WWTPs receive leachates in small quantities for further treatment. In these leachates samples and in samples of chemical toilets, that are considered difficult to treat, the decrease of the concentration of the tested compounds did not surpass 35-40% except for the parameter of total phosphorus which decreased per 55%.

Another type of wastewater difficult to treat is the effluents of olive oil industry. These effluents contain high COD concentrations and high concentrations of polyphenols that are toxic to the microorganisms used in the classic biological WWTPs. In the effluents of olive oil industry that have been treated in this study, the concentrations of all compound tested have been decreased by 60-90%, and more specifically COD concentrations by 78%, phenols by 75% and surfactants by 91%.

The results of the above tests are presented in Table II.

Regarding the behavior of metals to electrocoagulation treatment, the majority of the samples treated in this work had already very low metal concentrations; therefore it was not possible to monitor any electrocoagulation efficiency on them. However, leachates and samples from chemical toilets presented measurable metal concentrations and significant Al concentrations were determined in samples from septic tanks.

Metals concentrations in leachates had an average decrease of 60%, while Hg, the most toxic metal found in wastewater, had a decrease of 86%. In the samples from chemical toilets the average decrease of metals concentration was 50% (78% for Zn) and in the samples from septic tanks the decrease of Al concentration was 86%.

The tests results for metals are presented in the Table III below:

Table III: Decrease of the concentration of metals in wastewater samples after electrocoagulation treatment

	Septic tanks samples	Lechates	Chemical toilets
Cr		52%	39%
Cu		46%	
Pb		60%	
Zn		56%	78%
As		61%	55%
Hg		86%	
Al	86%	61%	51%
Average decrease		60%	50%

In order to examine the efficiency of electrocoagulation in wastewater disinfection, 15 samples have been tested for total coliforms, fecal coliforms and *E.Coli*. The concentrations of microorganisms in the untreated samples varied from $5x10^2$ to $6x10^6$ cfu/100ml. After electrocoagulation, complete absence of the above microorganisms was recorded, demonstrating thus that electrocoagulation provides full disinfection in wastewater samples.

V. CONCLUSION

The results of this study show that electrocoagulation is an effective method in wastewater treatment and provides a significant decrease of the unwanted chemical compounds of domestic wastewater and many types of industrial wastewater as well. The above observations fully agree with other conclusions regarding the efficiency of iron electrodes in removal of organic matter and specific organic compounds from wastewater [9], [11]-[13].

This study has been carried on in a bench scale apparatus and it is highly possible that electrocoagulation in industrial scale may be more efficient. Even if this is not the case, electrocoagulation can be a very efficient pretreatment method for wastewater that removes a high percentage of organic matter especially in the case of difficult substrates such as wastewater from olive oil industry. In addition, the high percentage of removal of toxic metals renders wastewater less toxic for the biological sludge during convenient treatment.

A very interesting conclusion is the complete sufficiency of electrocoagulation to disinfect wastewater, seen also in other studies [10]. Using electrocoagulation, WWTPs may omit the stage of chlorination which may produce undesirable organo-chlorinated compounds. In addition, European legislation sets

a higher allowable concentration of free chlorine in WWTP effluents that may stress even further the disinfection stage of the WWT procedure.

VI. REFERENCES

[1] J. Golden, R. Small, L. Pagan, C. Shang and S. Raghavan, *"Evaluating and Treating CMP Wastewater,"* Semiconductor International, 8 pp. , Oct. 2000.

[2] M. B Belongia., D.P. Haworth., C. J. Baygents and S. Raghavan, , *"Treatment of Alumina and Silica Chemical Mechanical Polishing Waste by Electrodecantation and Electrocoagulation"*, Journal of Electrochemical Society, vol. 146 (11), pp.4124-4130 ,1999.

[3] J. Janca, F. Checot, N. Gospodinova, S. Touzain and M. Spirkova, *"Transport Phenomena and Electrode Reactions Generated by an Electric Field in Colloidal Silica"*, J. Coll. Interface Science,vol.229, pp.423-430,2000.

[4] S. N. Abuzaid,, A. A. Bukhari and M. Z. Al-Hamouz, *"Groundwater coagulation using soluble stainless steel electrodes"*, Advances in Environmental Research, vol.6, pp.325-333 ,2002.

[5] O. Larue, E .Vorobiev, C. Vu and B. Durand, *"Electrocoagulation and Coagulation by Iron of Latex Particles in Aqueous Suspensions"*, Separation and Purification Technology,vol.31, pp.177-192 ,2003.

[6] M. J.Pearse, *"Historical Use and Future Development of Chemicals for Solid-Liquid separation in the Mineral Processing"*, Industry,Minerals Engineering, vol.16, pp.103-108,2002.

[7] J. S.Do and M.L.Chen , *"Decolorization of dye containing solution by electrocoagulation"*, Journal of Applied Electrochemistry,vol. 24, No.8, pp.785,1994.

[8] D.Mills, *"A new process for electrocoagulation"*, Journal AWWA,vol.92,No.6, pp.34-43,2000.

[9] V. Y.Baklan and I. P. Koleniskova , *"Influence of electrode material on the electrocoagulation"*, J. Aerosol Sci., 27/Suppl. 1:9:S209,1996.

[10] K.A.Bell and M. Abbaszadegan. *"Enhanced and Optimized Coagulation for removal of Particulate and Microbial Contaminants"*, Paper presented at the 1996 AWWA Ann. Conf. Toronto.

[11] Illhan, F.; Kurt, U.; Apaydin, O.; Gonullu, M.T. *"Treatment of leachate by electrocoagulation using aluminum and iron electrodes"*. Environ. Eng. Sci. 2008, 154, 381-389.

[12] Khansorthong, S.; Hunsom, M. *"Remediation of wastewater from pulp and paper mill industry by the electrochemical technique"*. Chem. Eng. J. 2009, 151, 228-234.

[13] Körbahti, B.K.; Tanyolaç, A. *"Electrochemical treatment of simulated textile wastewater with industrial components and Levafix Blue CA reactive dye: Optimization through response surface methodology"* J. Hazard. Mater. 2008, 151, 422-431.

Table II: Percentage of the decrease of concentration of various compounds in wastewater samples after electrocoagulation treatment

	Domestic wastewater	Septic tanks samples	Lechates	Chemical toilets	Olive oil industry
Total phosphorus	89%	85%	55%	56%	68%
Oil and grease	89%	92%			
BOD	73%	60%	28%	33%	64%
COD	69%	67%	22%	32%	78%
Phenols	69%	64%	23%	36%	75%
surfactants	63%	56%	37%	43%	91%
color	45%	54%	37%		
Total Nitrogen	25%	25%	37%	16%	61%
NH_4^+	8%	15%	28%		

Research of monthly precipitation trends in Libya and Slovakia

M. Zeleňáková, P. Purcz, I. Gargar, and H. Hlavatá

***Abstract*—**The objective of this study was to investigate precipitation trends in chosen climatic stations in Libya and Slovakia. We investigated 17 climatic stations in Libya and 20 climatic stations in Slovakia. The studied period was from 1971 to 2010 in Libya and from 1981 to 2010 in Slovakia. Monthly precipitation trends were detected by nonparametric Mann-Kendall statistical test. Negative trends of monthly precipitation were found in the analyzed rainfall gauging stations in Libya and vice versa positive trends of monthly precipitation were found in the analyzed rainfall gauging stations in Slovakia. November and August were observed to have the highest decreasing trends in Libya and March in Slovakia. All other month in Slovakia displayed increasing trends. In conclusion, Libya shown decreasing trend and Slovakia has an increasing trend of precipitation time series.

***Keywords*—**Climatic stations, Libya, Mann-Kendall test, monthly precipitation data, Slovakia.

I. Introduction

THE study of hydrological risk assessment is performed with goal to reduce impacts of droughts and floods. Droughts is the most complex but least understood of all natural hazards. It is broadly defined as "severe water shortage". Floods cause huge mainly material damages. Mentioned natural hazards cause loss of life, human and animal suffering and damage to economy and environment. The present study area is prone to extreme climate events such as drought and flood.

The Intergovernmental Panel on Climate Change [1] provides a comprehensive review of the potential impacts on climate. Climatic change is considered likely to increase runoff in the higher latitude regions because of increased precipitation on the other hand flood frequencies are expected to change also in some locations and the severity of drought events could increase as a result of those changes in both precipitation and evaporation. In all these considerations 'the issue' then becomes the effect of global warming and its impacts on the environment and water resources in particular. IPCC studies suggests an increase in the probability of occurrence of more frequent droughts, as well as floods, in the Atlantic Ocean and Caribbean Sea, the Mediterranean Sea, and the Indian and Pacific Oceans. Observations show that changes are occurring in the amount, intensity, frequency and type of precipitation. Pronounced long-term trends from 1900 to 2005 have been observed in precipitation amount in some places: significantly wetter in eastern North and South America, northern Europe and northern and central Asia, but drier in the Sahel, southern Africa, the Mediterranean and southern Asia. More precipitation now falls as rain rather than snow in northern regions. Widespread increases in heavy precipitation events have been observed, even in places where total amounts have decreased. These changes are associated with increased water vapour in the atmosphere arising from the warming of the world's oceans, especially at lower latitudes. There are also increases in some regions in the occurrences of both droughts and floods IPCC [2].

Several studies have given a great deal of attention to the potential impacts of climatic change and variability in several fields at international level. Trend analysis for meteorological time series is an important and popular tool for better understanding the effects of climate variation [3].

Many tests for the detection of significant trends in meteorologic time series can be classified as parametric and non-parametric methods [4], [5], (Zhang et al. 2006; Chen et al. 2007). Parametric trend tests are more powerful than non-parametric ones, but they require data to be independent and normally distributed. In comparison, non-parametric trend tests require only that the data be independent and can tolerate outliers in the data. On the other hand, they are insensitive to the type of data distribution [5], [6]. The Mann–Kendall (MK) test Kendall [7]; Mann [8] is a rank-based nonparametric test for assessing the significance of a trend, and has been widely used in hydro-meteorological trend detection studies [8]. The Mann-Kendall (MK) test is example of non-parametric tests that are applied for the detection of trends in many studies e.g. [3], [4], [5], [6], [9], [10], [11], [12], [13], [14], [15], [16], [17]. Recent studies of climate change have focused mainly on long-term variability of precipitation.

In recent years, a number of studies have been published focusing on the evolution of precipitation, drought conditions and moisture availability in the Mediterranean during the 20th century e.g. [3], [18], [19], [20]. Hydrological time series and rainfall distribution in Slovakia investigated [21], [22], [23], [24]. The detection of trends in meteorological data, in

The Centre was supported by the Slovak Research and Development Agency under the contract No. SUSPP-0007-09.

M. Zeleňáková is with the Technical University of Košice, Institute of Environmental Engineering, Vysokoškolská 4, 042 00 Košice, Slovakia (corresponding author to provide phone: +421-55-602 4270; e-mail: martina.zelenakova@tuke.sk).

P. Purcz and I. Gargar are with the same university (e-mail: pavol.purcz@tuke.sk; ebrahimkhalifa1@gmail.com).

H. Hlavatá is with the Slovak Hydrometeorological Institute, Ďumbierská 26, 042 00 Košice, Slovakia (e-mail: helena.hlavata@shmu.sk).

particular rainfall is essential for the assessment of the impacts of climate variability and change on the water resources of a region [25].

II. Material and Methods

A. Libya

Libya is situated in North Africa between Egypt and Algeria, with the Mediterranean to the north and Chad and Niger on its southern borders. Apart from the coastal strip and the mountains in the south, it is desert or semi desert. Libya's strategic position in North Africa and its abundant oil and gas resources made it an important trading partner for European states. North of Libya is influenced by Mediterranean depressions during winter season as a result of its geographical location, most of the precipitation falls as showers that produced from cumuliform clouds which moved along the coastal line. Some coastal areas and highlands are exposed sometimes for blowing of strong storms accompanied by heavy showers and sudden falling in atmospheric pressure. Rainfall averages ranged in these areas (north of Libya) from about 200 to 500 mm, with a maximum of recording on the regions of Jabal Al Akhdar "the Eastern Highlands" where was about 850 mm, and to about 750 mm on Jabal Nafusah areas "Western Highlands" [26]. The climate is Mediterranean along the coast and dry extreme desert is in the interior part of the country.

Monthly rainfall data recorded at 17 stations operated by Libya's Meteorological Service with data length from 1971 to 2010 were collected for this study. In all, a network stations (Table I) and 40 years of data were set up to study precipitation trend in Libya.

Table I Stations under the study in Libya

Station	Altitude (m)	Latitude (N)	Longitude (E)
Nalut	621	30°43'	20°00'
Garyan	796	32°05'	20°16'
Misurata	32	32°47'	22°35'
Sorman	18	24°13'	23°18'
Benina	129	30°08'	9°30'
Derna	26	29°45'	24°32'
Zuwarah	3	29°02'	21°34'
Al Jaghbub	-1	32°19'	15°03'
Ghadames	357	31°52'	10°59'
Sabha	432	27°01'	14°26'
Ajdabiya	7	32°49'	21°51'
Homs	22	31°12'	16°35'
Syrta	13	32°53'	12°05'
Shahat	621	32°00'	13°00'
Ghat	692	32°75'	12°57'
Al Kufrah	436	32°63'	14°30'
Jalu	60	25°13'	10°13'

B. Slovakia

When you submit your final version, after your paper has been accepted, prepare it in two-column format, including figures and tables. The territory under this study in Slovakia lies in the eastern part of the country, particularly in the Bodrog and Hornád river basins. The morphological type of terrain in the Hornád valley is dominated by rolling hills, higher and lower uplands. The southern sub-basin is part of a plain and the Slovakian Karst and is formed by moderately higher uplands [27]. The Bodrog river valley has varied climatic conditions. Precipitations are highly differentiated. The highest annual totals are mainly in the eastern border mountains and Vihorlat where rainfall totals are about 1000 mm. Decrease in total precipitation is quite marked directly to the south, where annual totals fall to below 800 mm. The Michalovce, Lastomír and Medzibodrožie lowlands rank among the driest in the eastern region (550 mm rainfall per year) [27].

Monthly precipitation data recorded at 20 stations operated by Slovak Hydrometeorological Institute with data length from 1981 to 2010 were collected for this study. Geographical location of stations is listed in Table II. 30 years of data were set up to study precipitation trend in the east part of Slovakia.

Table II Stations under the study in Slovakia

Station	Altitude (m)	Latitude (N)	Longitude (E)
Veľké Kapušany	103	48°33'	22°04'
Humenné	160	48°55'	21°54'
Michalovce	110	48°44'	21°56'
Snina	235	48°58'	22°08'
Svidník	218	49°18'	21°34'
Tisinec	216	49°12'	21°39'
Horovce	106	49°02'	21°45'
Bardejov	305	49°17'	21°16'
Hanušovce	165	49°02'	21°31'
Moldava nad Bodvou	218	48°36'	21°00'
Turňa nad Bodvou	180	48°36'	20°52'
Spišská Nová Ves	456	48°56'	20°33'
Spišské Vlachy	380	48°56'	20°48'
Kysak	262	48°51'	21°13'
Čaňa	173	48°36'	21°20'
Mníšek nad Hnilcom	410	48°48'	20°49'
Veľký Folkmár	379	48°51'	21°00'
Jakubovany	410	49°06'	21°08'
Vyšný Čaj	230	48°41'	21°24'
Chmeľnica	515	49°17'	20°43'

ISBN: 978-1-61804-224-8

C. Calculations

In this study non-parametric Mann-Kendall test is used for the detection of the trend in a time series. Mann-Kendall test [7], [8] is following statistics based on standard normal distribution (Z), by using Eq.(1).

$$Z = \begin{cases} \dfrac{S-1}{\sqrt{Var(S)}} & if \quad S > 0 \\ 0 & if \quad S = 0 \\ \dfrac{S+1}{\sqrt{Var(S)}} & if \quad S < 0 \end{cases} \tag{1}$$

$$S = \sum_{k=}^{n-1} \sum_{k+i}^{n} sgn(x_j - x_k) \tag{2}$$

$$sgn(x_j - x_k) = \begin{cases} +1 & if \left(x_j - x_k\right) > 0 \\ 0 & if \left(x_j - x_k\right) = 0 \\ -1 & if \left(x_j - x_k\right) < 0 \end{cases} \tag{3}$$

$$Var(S) = \left[n(n-1)(2n+5) - \sum_{i=1}^{m} t_i(t_i - 1)(2t_i + 5) \right] / 18 \tag{4}$$

where n is the number of data points, m is the number of tied groups (a set of sample data having the same value).

According to this test, the null hypothesis H0 states that the depersonalized data (x_1, …, x_n) is a sample of n independent and identically distributed random variables. The alternative hypothesis H1 of a two-sided test is that the distributions of x_k and x_j are not identical for all k, $j \leq n$ with $k \neq j$. The significance level is chosen as $\alpha = 0{,}05$ and $Z_{\alpha/2}$ is the value of normal distribution function, in this case $Z_{\alpha/2} = 1.95996$. Hypothesis H0 - no trend is if ($Z < Z_{\alpha/2}$) and H1 - there is a trend if $Z > Z_{\alpha/2}$. Positive values of Z indicate increasing trends, while negative values of Z show decreasing trends.

The magnitude of the trend was determined using Sen`s estimator. Sen's method assumes a linear trend in the time series and has been widely used for determining the magnitude of trend in hydro-meteorological time series e.g. [16], [17], [29], [30]. In this method, the slopes (β) of all data pairs are first calculated by

$$\beta = Median\left((x_j - x_k)/(j - k) \right) \tag{5}$$

for i = 1, 2, ..., N,.where x_j and x_k are data values at time j and k ($j > k$), respectively and N is a number of all pairs x_j and x_k. A positive value of β indicates an upward (increasing) trend and a negative value indicates a downward (decreasing) trend in the time series.

III. Results and Discussion

The results of trend analysis for the precipitation are discussed in the following. The results of precipitation analysis are presented for monthly data for Libya (Table III) and for Slovakia (Table IV). The evaluation was done for the time period from November to October. Data series for the 40 years period was considered for trend detection. In the Sen's method the slope of all the data points are calculated and their median value is the Sen's estimator of slope.

Table III Sen`s estimator for monthly precipitation in Libya

No	Station	Month					
		XI	XII	I	II	III	IV
1	Nalut	-	+	+	-	-	-
2	Garyan	-	-	-	+	-	+
3	Misurata	+	+	+	+	-	+
4	Sorman	- -	-	-	+	+	+
5	Benina	- -	-	-	-	-	-
6	Derna	-	+	+	+ +	+	+ +
7	Zuwarah	-	-	-	- -	-	-
8	Al Jaghbub	-	-	-	-	-	- -
9	Ghadames	-	-	+	-	-	-
10	Sabha	-	+	+	-	-	-
11	Ajdabiya		-	+	-	-	+
12	Homs	- -	+ +	+ +	+	+	- -
13	Syrta	+	+	+ +	+ +	-	+
14	Shahat	+	+ +	+ +	+ +	+	+
15	Ghat	-	+	+	+	+	+
16	Al Kufrah	-	-	-	-	-	-
17	Jalu	+	+	+	+	+	+

No	Station	Month					
		V	VI	VII	VIII	IX	X
1	Nalut	-	-	-	-	-	-
2	Garyan	-	+	-	+	-	+
3	Misurata	-	+	+	+ +	+	-
4	Sorman	- -	-	-		-	-
5	Benina	+	-	-	- -	-	-
6	Derna	-	-	-	-	-	-
7	Zuwarah	+	+	-	-	+	- -
8	Al Jaghbub	-	-	-	-	-	-
9	Ghadames	-	-	+	-	-	-
10	Sabha	+	+	+	+	+	+
11	Ajdabiya	- -	-	+	-	-	-
12	Homs	+	+	+	-	+ +	+ +
13	Syrta	+	-	-	+	- -	+
14	Shahat	+ +	-	-	-	+ +	+ +
15	Ghat	+	+	+	+	+	+
16	Al Kufrah	-	-	+	-	-	-
17	Jalu	+	-	+	+	+	+

Regarding trend analysis of monthly precipitation data (Table III) there is no clear trend. No trend was proved in the stations situated mostly in the desert – Al Jaghbub, Ghadames,

Sabha, Ghat, Al Kufrah, Jalu. There is no or very small values of rainfall in general. Declining trend was demonstrated in the stations Nalut, Sorman, Benina and Zuwarah. In the stations Sorman, Benina and Zuwarah the Sen's estimator is statistically significant for two months. High statistically significant negative values appear in November. In the stations Homs, Syrta Shahat and Derna the rising trend in rainfall time series was demonstrated. The value of the Sen's estimator is statistically significant for two months in Syrta and Derna, for four months in Homs and for six months in Shahat. Large statistically significant positive values of the Sen's estimator in these stations were in January. Positive and negative values were evenly balanced and no or only for one month statistically significant trend was proved in stations Garyan, Misurata and Ajdabiya.

Table IV Sen`s estimator for monthly precipitation in Slovakia

No	Station	Month					
		XI	XII	I	II	III	IV
1	Veľké Kapušany	+	+	+	+ +	-	+
2	Humenné	+	-	+	+	-	+
3	Michalovce	+	+	+	+	-	+
4	Snina	+	-	-	+	-	-
5	Svidník	+	-	+	+	-	+
6	Tisinec	+	-	+	+	-	+
7	Horovce	+	+	+	+ +	+	+
8	Bardejov	-	-	+	+	-	+
9	Hanušovce	-	+	+ +	+	-	+
10	Moldava nad Bodvou	-	+	+	+	-	+
11	Turňa nad Bodvou	+	+	+	+ +	-	+
12	Spišśská Nová Ves	-	+	+ +	+	-	+
13	Spišské Vlachy	-	+	+ +	+	+	+
14	Kysak	-	+	+	+	-	-
15	Čaňa	+	+	+	+	-	+
16	Mníšek nad Hnilcom	+	+	+ +	+	+	+
17	Veľký Folkmár	+	+	+ +	+	+	+
18	Jakubovany	-	-	+	+	-	+
19	Vyšný Čaj	+	-	+	+	-	+
20	Chmeľnica	+	-	+	+	+	+

Rainfall trends show variability in magnitude and direction of trend from one station to another. It depends upon many factors, e.g. latitude, altitude. Significant positive trend is in stations – Veľké Kapušany, Turňa nad Bodvou, Spišská Nová Ves, Spišské Vlachy, Mníšek nad Hnilcom (January, June, July), Veľký Folkmár. Decreasing trend of precipitation was found only in March all other months prove increasing trend of precipitation. The trend slope is increase of annual precipitation e.g. in Mníšek nad Hnilcom it is 0.057 mm/year. In conclusion, trend analysis of rainfall data series for 1981–2010 showed increasing trend in Slovakia.

Table IV Sen`s estimator for monthly precipitation in Slovakia

No	Station	Month					
		V	VI	VII	VIII	IX	X
1	Veľké Kapušany	+	-	+	+ +	+	+
2	Humenné	+	-	+	+	+	-
3	Michalovce	+	+	+	-	+	-
4	Snina	-	-	+	+	+	+
5	Svidník	+	+	+ +	+	-	+
6	Tisinec	+	+	+	+	+	+
7	Horovce	+	+	+	-	+	-
8	Bardejov	+	+	+ +	+	-	+
9	Hanušovce	-	-	+	+	+	-
10	Moldava nad Bodvou	-	-	+	+	+	-
11	Turňa nad Bodvou	-	+	+ +	+	+	-
12	Spišśská Nová Ves	-	+	+ +	+	+	+
13	Spišské Vlachy	-	+	+ +	+	+	+
14	Kysak	-	-	+ +	+	+	-
15	Čaňa	+	+	+	+	+	+
16	Mníšek nad Hnilcom	-	+ +	+ +	+	+	+
17	Veľký Folkmár	-	+	+ +	+	+	+
18	Jakubovany	-	+	+ +	+	+	+
19	Vyšný Čaj	+	+	+	-	+	+
20	Chmeľnica	+	+	+	+	+	+

IV. Conclusion

This paper deals with the research of monthly precipitation trends in climatic stations in Libya and Slovakia. The non-parametric Mann-Kendall statistic test was applied to detect trends and to assess the significance of the trends in the time series. The evaluation was done for the time period from November to October.

Trend analysis of rainfall data series for 1970–2010 did not show any clear trend for Libya as a whole although mainly decrease in precipitation was proved. As expected, rainfall trends show large variability in magnitude and direction of trend from one station to another. It is clear that slight climatic changes may have affected the magnitude and timing of the precipitation within the study area. High statistically significant negative values appear in November and high statistically significant positive values appear in January.

ISBN: 978-1-61804-224-8

Trends analysis in precipitation data in eastern Slovakia was carried out in the time period 1981–2010. Data used in the present study were acquired from Slovak Hydrometeorological Institute. Almost all the gauging stations in Slovakia show positive trend of monthly precipitation. The increase of precipitation – significant positive trend – was proved in stations Turňa nad Bodvou, Mníšek nad Hnilcom, Veľký Folkmár. Monthly rainfall data series show increasing trend for eastern Slovakia's stations. Significant positive trend in precipitation is proved in July. Decreasing trend is demonstrated only in March.

The rainfall of a certain place depends upon many factors and some weather conditions. These include latitude, altitude, topography, and distance from water bodies or other wet areas.

ACKNOWLEDGMENT

The Centre was supported by the Slovak Research and Development Agency under the contract No. SUSPP-0007-09.

REFERENCES

[1] IPCC Working Group II: *Impacts, Adaptation and Vulnerability. Extreme high temperature and precipitation events*. ch. 17, Available: http://www.ipcc.ch/ipccreports/tar/wg2/index.php?idp=625

[2] Climate Change: Working Group I: *The Physical Science Basis. How is Precipitation Changing?* 2007. Available: http://www.ipcc.ch/publications_and_data/ar4/wg1/en/faq-3-2.html

[3] M. Zelenakova, P. Purcz and I. Gargar, "Trends in precipitation and temperature in Lybia," in *6th World Aqua Congress: Water Vision 2050*, New Delhi, 2012, pp.37-48.

[4] Q. Zhang, C. Liu, CY. Xu, YP. Xu and T. Jiang, "Observed trends of water level and streamflow during past 100 years in the Yangtze River basin," *J Hydrol*, vol. 324, pp. 255–265, 2006.

[5] H. Chen, S. Guo, CY. Xu and V. P. Singh, "Historical temporal trends of hydro-climatic variables and runoff response to climate variability and their relevance in water resource management in the Hanjiang basin," *J Hydrol*, vol. 344, pp.171–184, 2007.

[6] S. Yue, P. Pilon and G. Cavadias, "Power of the Mann-Kendall and Spearman'S rho tests for detecting monotonic trends in hydrological series," *J Hydrol*, vol. 259, pp.254–271, 2002.

[7] M. G. Kendall, Rank Correlation Measures. London: Charles Griffin & Co., 1975.

[8] H. B. Mann, "Non-parametric tests against trend," *Econometrica*, vol. 13, no. 3, pp. 245-259, 1945.

[9] D. H. Burn and M. A. Hag Elnur, "Detection of hydrologic trends and variability," *J Hydrol*, vol. 255, pp. 107-122, 2002.

[10] M. Shadmani, S. Marofi and M. Roknian, "Trend Analysis in Reference Evapotranspiration Using Mann-Kendall and Spearman's Rho Tests in Arid Regions of Iran," *Water Resources Management*, vol. 26, pp. 211 - 224, 2012.

[11] A. Gadgil and A. Dhorde," Temperature trends in twentieth century at Pune, India," *Atmos Environ*, vol. 39, pp. 6550–6556, 2005.

[12] D. P. Lettenmaier, E. F. Wood and J. R. Wallis, "Hydro-climato-logical trends in the continental United States, 1948–88," *Journal of Climate*, vol. 7, pp. 586–607, 1994.

[13] E. Kahya and S. Kalayci, "Trend analysis of streamflow in Turkey," *J Hydrol*, vol. 289, pp. 128–144, 2004.

[14] Z. L. Li, Z. X. Xu, J. Y. Li and Z. J. Li, "Shift trend and step changes for runoff time series in the Shiyang River Basin, Northwest China," *Hydrol Process*, vol. 22, pp.4639–4646, 2008.

[15] B. Onoz and M. Bayazit, "Power of the Statistical Tests for Trend Detection," *Turkish J. Eng. Env. Sci*., vol. 27, pp. 247 – 251, 2003.

[16] T. Partal and E. Kahya, "Trend analysis in Turkish precipitation data," *Hydrological Processes*, vol. 20, pp. 2011–2026, 2006.

[17] S. Yue and M. Hashino, "Temperature trends in Japan: 1900–1990," *Theoretical and Applied Climatology*, vol. 75, pp. 15–27, 2003.

[18] A. Pauling and H. Paeth, "On the variability of return periods of European winter precipitation extremes over the last five centuries," *Clim. Past Discuss*., vol. 2, pp. 157–189, 2006.

[19] J. Lopez-Moreno, S. Vicente-Serrano, L. Gimeno and R. Nieto, "Stability of the seasonal distribution of precipitation in the Mediterranean region: Observations since 1950 and projections for the 21st century," *Geophys. Res. Lett*., vol. 36, no. 10, doi:10.1029/2009GL037956, 2009.

[20] P. M. Sousa, R. M. Trigo, P. Aizpurua, R. Nieto, L. Gimeno and R. Garcia-Herrera, "Trends and extremes of drought indices throughout the 20th century in the Mediterranean," *Nat. Hazards Earth Syst. Sci*., vol. 11, pp. 33–51, 2011.

[21] J. Parajka, S. Kohnova, R. Merz, J. Szolgay, K. Hlavcova and G. Blöschl, "Comparative analysis of the seasonality of hydrological characteristic in Slovakia and Austria," *Hydrological Sciences–Journal–des Sciences Hydrologiques*, vol. 54, no. 3, p. 456-473, 2009.

[22] S. Kohnova, M. Lapin, J. Szolgay and L. Gaal, "Methodology for the selection of 10-day maximum precipitation totals and their statistical analysis in the upper Hron region," *Contributions to Geophysics and Geodesy*, vol. 35, no.3, 2005.

[23] L. Gaal, J. Kysely and J. Szolgay, "Region-of-influence approach to a frequency analysis of heavy precipitation in Slovakia," *Hydrol. Earth Syst. Sci*., vol. 12, pp. 825–839, 2008.

[24] J. Szolgay, J. Parajka, S. Kohnova and K. Hlavcova, "Comparison of mapping approaches of design annual maximum daily precipitation," *Atmospheric Research*, vol. 92, no. 3, pp. 289–307, 2009.

[25] A. Sarkar, R. D. Singh and N. Sharma, "Climate variability and trends in part of Brahmaputra river basin. *India Water Week 2012 – Water, Energy and Food Security: Call for Solutions*, New Delhi, 2012.

[26] K. I. Elfadli, "Precipitation data of Libya," Libyan National Meteorological Center, 2009.

[27] M. Zelenakova, "Preliminary flood risk assessment in the Hornád watershed," in *River Basin Management 5*, Southampton: Wessex Institute of Technology, pp. 15-24, 2009.

[28] M. Zelenakova and L. Ganova, Integrating multicriteria analysis with geographical information system for evaluation flood vulnerable areas. in *SGEM 2011: 11th International Multidisciplinary Scientific GeoConference*, Sofia, pp. 433-440, 2011.

[29] P. K. Sen, "Estimates of the regression coefficient based on Kendall's tau", *Journal of the American Statistical Association*, vol. 63, pp. 1379 - 1389, 1968.

[30] S. K. Jain, V. Kumar and M. Sahariad, "Analysis of rainfall and temperature trends in northeast India", *Int. J. Climatol*., vol. 33, no. 4, pp. 968 – 978, 2013.

Possibilities to Reuse Batteries for Reduction of Waste Volume.

Baťa R., Bačinová, I.

***Abstract*—** The amount of waste generated in the production and social sphere is increasing. Therefore, it is necessary to introduce certain measures by which this will be regulated. One of biggest problem of the waste management is related to portable batteries, The aim was to verify whether the selected number of batteries that had been submitted for recycling were been really useless or just damaged by improper use.

***Keywords*—**Accumulators, recovery, waste disposal, savings, waste reduction.

I. Introduction

Reduction of wastes and their subsequent safe, environmental and economic removal is currently one of the biggest economic problems around the world. "*The basic legislation of the European Parliament and of the Council that constitute a framework for Community action in the field of water policy are the Directive 2000/60/ES of The European Parliament and of The Council of 23 October 2000 that establish a framework for Community action in the field of water policy, and the Council Directive 91/271/EEC of 21 May 1991 that addresses the urban waste –water treatment*" [7]. The amount of waste generated in the production and social sphere is increasing. Therefore, it is necessary to introduce certain measures by which this will be regulated. Waste disposal must be changed for all producers of waste, i.e. not only for manufacturers but also among the general public. The waste disposal should be both economically viable and environmentally acceptable. [5], [10]

One of biggest problem of the waste management is related to portable batteries, which are a part of everyday life and which are abundantly used in various devices such as cameras, mobile phones, lights, MP3 or MP4 players, toys and various home appliances, etc. [3,6,8].

The aim was to verify whether the selected number of batteries that had been submitted for recycling were been really useless or just damaged by improper use (or charging). And subsequently determinate, whether this state of battery cells will be already permanent, or whether there is a chance, that these batteries become reusable in some cases.

This work was supported by the specific university research.

II. Determination of the problem

A. The hierarchy of the waste disposal

In 2008, the EU adopted a new directive on waste (75/442/EEC), which contains the basic principles of waste management - the five step hierarchy.

All EU countries are required to comply with these mandated preferences (in order from top to bottom), which relate to the waste management. Waste should go through all the steps, especially through the step further possible utilization (recycling into new products or energy production). In case it is not possible to further use it, then comes the economic method of their elimination. [2,3,6]

B. Portable batteries and accumulators

About 100 million new battery cells are sold every year in the Czech Republic, I.e. 14 pieces per person. Unfortunately, just a small part of these batteries is given back to recycling. In 2012, everyone gave back in average 2.25 of used cells, which is not enough to meet EU requirements. (In 2012, everyone should give back in average 4 discharged accumulators.) [1,4] Most people buy more primary (classical) cells than secondary (rechargeable), from the environmental point of view this should be contrariwise.

The negative environmental impact of batteries and accumulators consists in the content of toxic substances (cadmium, lead, mercury, nickel, lithium), these can contaminate ground water, plants, animals, and soil for up to 50 years. A number of measures is accepted to reduce the environmental burden - reduction of toxic substances, separate take-back and reuse of secondary cells.

According to the results of the French study, the rechargeable batteries have less impact on the environment than non-rechargeable batteries. Using of accumulators (instead of non-rechargeable batteries) would prevent about 330,000 tons of waste generated around the world, in Europe the waste production would decrease by about 99,000 tons. In the Czech Republic this would mean about 2,000 tons of waste batteries less yearly, i.e. 66% of the weight of all portable articles, which are yearly placed on the market [2,3].

C. Problem solution

As already mentioned, rechargeable batteries have less impact on the environment than conventional disposable batteries. The question is if people know how to use these

batteries properly. Of course, there are a plenty of chargers offered on the market. Cheaper chargers are of a poor quality and they probably degrade and considerably shorten service life of the batteries. Greater consumption may suit manufacturers of these chargers and accumulators, because it enhances their turnover, but at the expense of the environmental burden.

To verify the assumption that people do not handle rechargeable batteries correctly and throw away still useful cells, the sample of accumulators given back to various collection boxes in different stores (mostly electronic stores) to recycling was selected. Analyzed sample comes from the Czech Republic, mostly from the Regions Hradec Králové and Pardubice and includes 186 used batteries consigned for recycling, the parameters of which were analyzed using a special charger - Charge Manager 2015, which was used for the study.

The research analyzed the total amount of 186 used accumulators, which have a different brand, size, composition and specifications. Table 1 shows a sample of analyzed data, and in addition to the above mentioned characteristics of the batteries there is also newly acquired capacity after treatment, then there is column that indicates success of recovery, and a note explaining the status of a battery.

Table I: The selected accumulators

Producer	Capacity (mAh)	Size	Capacity after treatment (mAh)	Successful recovery yes (1) / no (0)	Type	Note
GP	2050	AA	2178	1	NiMH	
GP	2050	AA	2306	1	NiMH	
Tronic	2100	AA	125	0	NiMH	too low capacity
Tronic	2100	AA	72	0	NiMH	too low capacity
Hama	2500	AA	376	0	NiMH	too low capacity
Hama	2500	AA	1273	1	NiMH	
Energizer	2500	AA	0	0	NiMH	not possible to charge
Hama	2500	AA	1350	1	NiMH	
Ucar	750	AA	0	0	NiCd	not possible to charge
CE	600	AAA	595	1	NiMH	
Multiplex	600	AA	244	1	NiCd	
Sono	800	AA	950	1	NiCd	

Source: own

Research has shown that 18% (34 pcs) of accumulators were not possible to revive, but 82% of the used accumulators can be reused (see Fig. 1), i.e. 152 accumulators from a total amount of 186 units. This means that consumers hand into the takeback still usable cells. This situation is mainly caused by ignorance of users by producers and of course by inexpensive chargers that are marketed and widely used by consumers. Compared special charger that is able to charge the battery as 1,000 times, inappropriate chargers cause after about 100-150 charging cycles, the inapplicability of the cells.

It should also be noted, that this analysis is based on data from only one formatting cycle. But it can be expected that due to the re-formatting of batteries, these results can be further improved by re-formatting with more formatting cycles. This assumption was tested on a very small sample (35 cells) yet, the improvement of the characteristics of these batteries was confirmed. Because of a very small selection, we cannot make general conclusions.

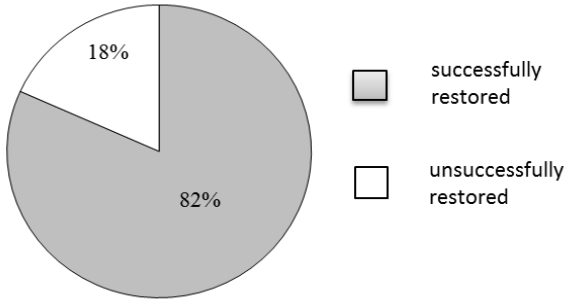


Fig. 1: Success in restoring used accumulators

Source: own

Fig. 2 divides the entire sample into three groups. Batteries were divided by new capacity, measured by Charger Charge Manager 2015 after recovery.

The first group includes batteries, which amounted to 0-69% of the capacity after the recovery, this group represents 51 pieces. The second group includes batteries with new capacity from 70 to 99% of the capacity stated by the producer, which includes 56 pieces. Finally, the last group, which reached even above 100% of its original capacity. This group represents 79 pieces of the cells that were given in take-back by the consumers. Batteries charged over 70% of their original capacity are further normally usable, actually some of them exceeded their reported capacity of over 100%. It is very surprising that despite of this fact, they were thrown away by their users, this indicates a huge profusion of the batteries and accumulators.

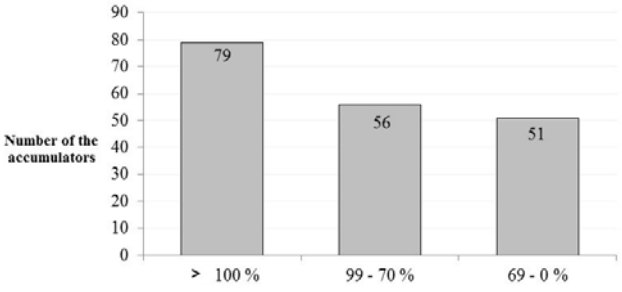


Fig. 2 Accumulators according to the new capacity after recovery.

Source: own

The next two figures complement the previous Fig. 2. Batteries charged over 70% are recorded in multiple groups so as to clearly see this unexpected result. The largest parts of both graphs represent the batteries, which have reached new capacity in percentage terms from 91 to 110%. This is an excellent result, however, it requires to ensure that users are really informed about this fact. This would subsequently

reduce the impact on the environment and limit the production of this type of waste.

Fig. 3 shows a group of batteries charged to 100% of their original capacity. 10 cells received 70-80% of their original capacity, there are 11 pieces of the cells which are ranging from 81 to 90% of their original capacity and the largest group comprising 35 batteries, includes all cells, which reached new capacity from 91 to 99% of original producer's reported capacity.

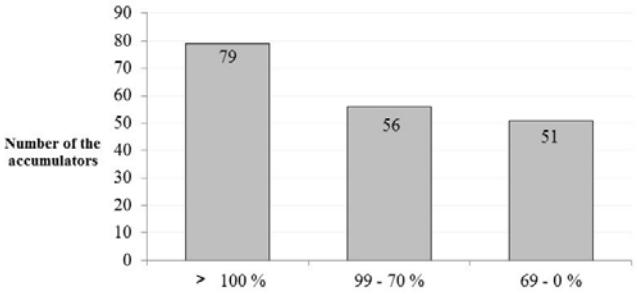


Fig. 3 - Chargeable at 70-99% of the original capacity

Source: own

The results for the group of batteries with best recovery results from chosen sample can be seen in Fig. 4. Here are included all batteries, which got over 100% of their original capacity after being restored by the special charger. 56 pieces ranged from 100 to 110% of the capacity, 18 pieces achieved capacity from 111 to 120% and even 5 batteries are between 121 to 150% of their capacity reported by the producer.

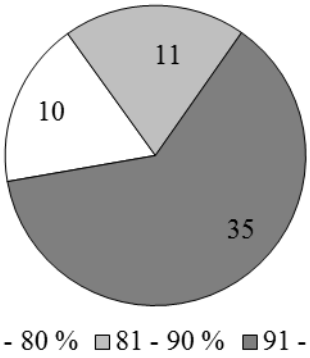


Fig. 4 – Charging at 100 – 150 % of the original capacity

Source: own

Furthermore, the batteries were divided into 4 groups according to their original capacity, which can be seen in Fig. 5. The first group includes the batteries with a capacity of 0 to 700 mAh, this group is 34 units (18%). The second group includes 46 batteries (25%), which have a capacity between 701 and 1400 mAh. The third group with a capacity of 1 401-2 100 mAh includes 33 batteries, which means 18%. Finally, the fourth group with the largest capacity (from 2 101 to 2 800 mAh) contains 73 recovered batteries, which is 39% of the total.

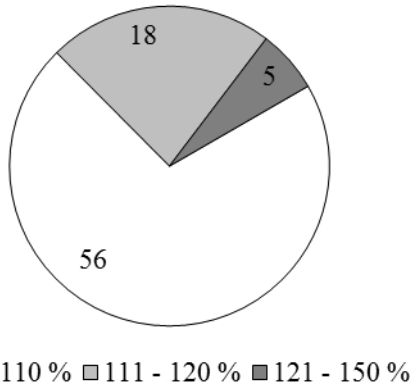


Fig. 5 – Number of accumulators in each capacity group in mAh

Source: own

Used batteries were charged by a special charger Charge Manager 2015 in the mode called alive, to determine which can be re-used and what capacity can be restored. There are remaining four groups according to their original capacity. From Fig. 6 it is clear that the groups are not significantly different. For the first group, which contains batteries with capacity from 0 to 700 mAh, we can say that the slightly lesser status (65%) can be justified by the fact, that in this category, there are some very old cells, for which have failed their restoration. For other groups, the average capacity of recovered accumulators moves to 80% of their original value. The best was the group with the capacity of 1 401 to 2 100 mAh, which charged at 84% of the original capacity in average.

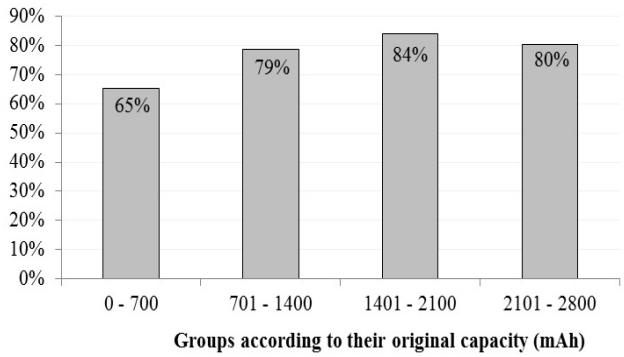


Fig. 6 – The average charge after the recovery according capacity

Source: own.

D. Calculation of savings potential

In 2011, the retail network of the Czech Republic sold nearly 100 millions of new batteries. In every household in the Czech Republic at the moment is an average of 10 used batteries. In the Czech Republic in 2012 921 tons of batteries were given back for recycling. The quantity of batteries placed on the market in the years 2010 - 2012 is shown in Table II.

ISBN: 978-1-61804-224-8

Table II The amount of batteries placed on the market

The amount of batteries placed on the market in	2010	2011	2012
Type	Weight (t)	Weight (t)	Weight (t)
Alkaline	998,888	1085,813	1322,997
Zinc	1068,407	928,007	956,62
Lithium	18,357	21,718	21,277
Button cells	20,31	20,877	24,164
Nickel-cadmium	187,517	153,724	158,092
Nickel-metal hydride	218,569	186,864	170,209
Li-Ion/Li-Pol	233,181	246,939	252,542
Leaden	320,479	430,931	480,593
Alkaline accumulators	2,045	3,826	2,387
Sum	*3067,753*	*3078,699*	*3388,881*

Source: [1]

It is more favorable for the environment if the battery can be used repeatedly. Disposable batteries pollute the environment more particularly because of considerably greater volume of waste produced.

It is evident from the graph in fig. 7 that the sale of conventional rechargeable cells shows a decreasing trend, especially for battery Nickel-metlahydrid while, as shown in the graph in fig. 8, the sale of disposable batteries, especially alkaline shows a growing trend.

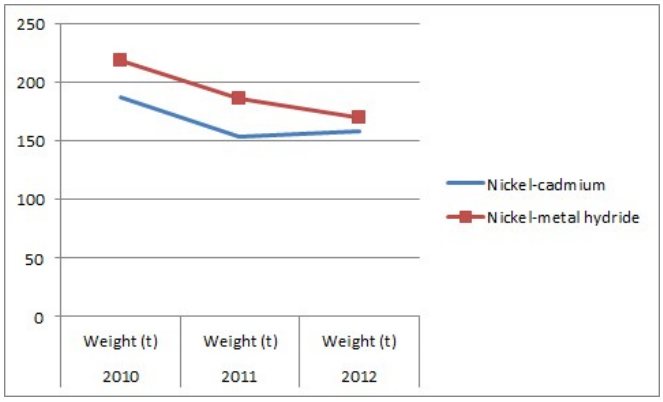


Fig. 7: The sale of conventional rechargeable cells in 2010 - 2012

Source: [1]

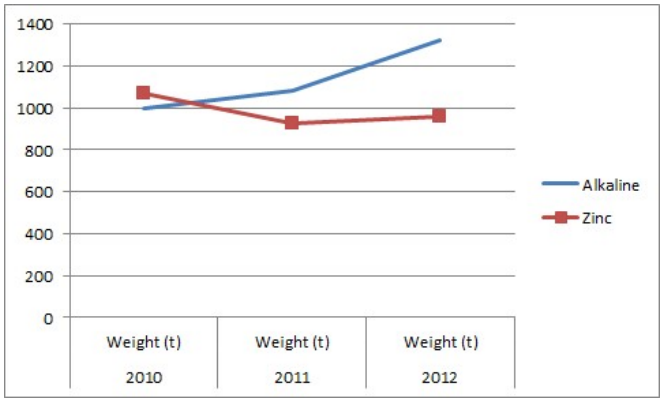


Fig. 8: The sale of disposable batteries in 2010 -2012

Source: [1]

This may be caused, among others, by dissatisfaction with the characteristics of rechargeable batteries. Firstly, they are relatively expensive and require a battery charger, secondly, they are not able to last, as mentioned above, the number of charge cycles featured by the manufacturer. If we build on the results for the analyzed sample and apply them on the global data, it is possible to make the assumption that at least 82% of the accumulators purchased each year were not necessary to produce as they could have been replaced by reformatted, earlier produced accumulators.

Let us further consider that using a normal charger, the battery becomes unusable after app. 200 charging cycles, while by charging in pulse mode and correct treatment it increases to 1000 charging cycles. This relationship could be described mathematically by formula:

$$Q=(A \times 0,18)/5 \quad (1)$$

Where

Q is the maximum number of accumulators needed in case of proper handling in t/year,

A is the number of batteries placed on the market in a given year in t

Similarly, can be expressed the achievable savings in t batteries, which did not need to be made as:

$$S = A-Q \quad (2)$$

where S are the savings expresed in t/year.

Substituting the values from Table II to the formula (1) and (2) we obtain the values shown in Table III.

Table III Saving potential

The amount of batteries realy needed on the market	2010	2011	2012
Type	Weight (t)	Weight (t)	Weight (t)
Nickel-cadmium	6,750612	5,534064	5,691312
Nickel-metal hydride	7,868484	6,727104	6,127524
Saving potential			
Nickel-cadmium	180,766388	148,189936	152,400688
Nickel-metal hydride	210,700516	180,136896	164,081476

Source: own, according [1]

From the above it is clear that many of the accumulators were probably produced because of incorrect dealing with these types of accumulators. The sample selected due to their size, of course, may not be fully representative and it is certainly the question of the extent to which the analysis can show the whole. The overall ratio of successfully renewed accumulators in a larger sample may not as favorable as in the sample chosen. On the other hand, it is possible that a part of the 18% longer unusable accumulators were damaged by improper handling. In conclusion, the analysis showed that there is probably a great potential for possible savings. This can present a challenge for the subsidy policy in the field of public

administration [9].

As a measure to solve this problem an information campaign could be conducted or chargers more appropriate for a particular type of accumulators could be made more price favorable.

At the same time, it should be stated on the packaging that if the accumulators will not be charged by the attached charger, the number of cycles will not be 1000, but only e.g. 200.

E. Conclusion

To determine whether the batteries are really useless or just damaged by improper use (or improper charging), batteries were chosen which had been already located in the collection boxes for the take-back.

The results confirmed the assumption. It can be said, that an excessive amount of new batteries is produced and a lot of them is wasted. It should be noted that the accumulators get in large numbers into the mixed waste cans and bins, instead of recycling.

From the analysis it was found that 82% of cells from the sample are able to recover.

Total 135 accumulators get at least compliant state (at least 70% of the original capacity) after the recovery, which means that it is possible to continue using them. Due to the low quality chargers, the accumulators probably devaluate, their capacity and durability decreases. Special charger Charge Manager 2015 was able not only to recover the majority of the batteries, but also counteract the memory effect and self-discharge of the cells. Even 42% of the total battery selection (i.e. 79 cells) reached over 100% of their capacity reported by the producer after the recovery, which is an excellent result.

Finally, it must be emphasized, how little attention is paid to this problem. People are little aware of the fact that concerns the whole issue of waste, and often do not realize what happens to the accumulators which are thrown away just as unsorted municipal waste. Suggestions for improving the situation may be to increase of the public awareness through a variety of media devices or projects that are carried out by companies that deal with the take-back of batteries and accumulators. Important now and especially for the future is to recognize this fact and adjust the behavior of consumers, so that batteries would be used as efficiently and quality chargers would reduce the production of this type of waste.

REFERENCES

[1] ECOBAT. Annual report on the implementation of the obligation to return a separate used batteries and accumulators. [in Czech] Roční zpráva o plnění povinnosti zpětného odběru a odděleného sběru baterií a akumulátorů. [online]. 5.1. 2014 [cit. 2014-05-01] http://www.ecobat.cz/userfiles/File/ECOBAT_Rocni_zprava_2010_prenosne_baterie.pdf.

[2] ECOCHEESE. Interesting - Did you know that [in Czech] Zajímavosti - Věděli jste, že [online]. 15. 4. 2011 [cit. 2011-15-04] http://www.ecocheese.cz/zajimavosti..

[3] Jackson, C. EP supported the new directive on waste. [in Czech] EP podpořil novou směrnici o odpadech [online]. 17. 6. 2008 [cit. 2011-15-04] <http://www.europarl.europa.eu/sides/getDoc.do?language=cs&type=IM-PRESS&reference=20080616IPR31745>

[4] Kic-odpady. Legislation [in Czech] Legislativa [online]. 17. 12. 2009 [cit. 2011-15-04] http://www.kic-odpady.cz/legislativa.html

[5] KURAŠ, M. Waste recovery and disposal. [in Czech] Odpady, jejich využití a zneškodňování. 1. iss. Praha: Český ekologický ústav, 1994. Pages 243. ISBN 80-85087-32-4.

[6] Ministery of Environment. Batteries and accumulators [in Czech] Baterie a akumulátory [online]. 15. 4. 2011 [cit. 2011-15-04] http://www.mzp.cz/cz/baterie_akumulatory.

[7] Myšková, R., Ilona, O., Petr, C., Šatera, K. Assessment of environmental and economic effects of environmental investment as a decisions problem. WSEAS Transactions on Environment and Development. Volume 9, Issue 4, October 2013, Pages 268-277. ISSN: 1790-5079.

[8] Odpadjeenergie. EU Framework Directive on Waste / hierarchy. [in Czech] Rámcová směrnice EU o odpadech/hierarchie [online]. 15. 4. 2011 [cit. 2011-15-04] http://www.odpadjeenergie.cz/legislativa/ramcova-smernice-eu-o-odpadech-hierarchie.aspx

[9] Pastuszkova, E. Does public administration reach performance in the sphere of subsidies relations? The case of the Czech Republic. International Journal of Mathematical Models and Methods in Applied Sciences. Volume 7, Issue 4, 2013, Pages 396-403. ISSN: 1998-0140.

[10] Urbaniec, M., Vachevskyi, M. International marketing of globalization and the reproducton mechanism of world economy. Actual Problems of Economics. Volume 135, Issue 9, 2012, Pages 78-85. ISSN: 1993-6788.

Bať a R. * Pardubice, 1974. After completing a Bc. in Economics and Administration in 1993 from the University of Pardubice (Czech Republic), Robert received both his dipl.Ing and PhD at the University of Pardubice, partly in parallel studies on International graduated school of Zittau (Germany).

Robert has worked in Germany on a international projects, later then as an assistant professor on the University of Pardubice.

Dr. Bať a is member of the expert committee of Technology Agency of the Czech republic,

Bačinová I. * Chrudim, 1990. After completing a Bc in Economic Policy and Administration in 2012 Ilona continues in the master's program. In the framework of the specific student research project, is involved in the processing of this paper.

Meeting Rural Water Supply Challenges: Lessons from a South African Groundwater Supply Scheme

Jeremiah Mutamba

***Abstract*—** Accessing safe drinking water continues to be one of the most complex challenges facing African rural communities. Despite considerable and concerted investments over the past decade, many rural communities still encounter huge clean water supply challenges – even to the extent of women walking for kilometres to find clean water. With its numerous advantages, groundwater supply forms a significant and integral part of the solution to address rural water issues in Africa and beyond. This paper outlines the plight of rural communities in accessing clean water and, using a case study project set in South Africa, brings to fore approaches for improving rural water supplies. The paper first outlines the South African rural water supply outlook against the limited water resources of the country. It then highlights the country's groundwater resources concluding by drawing case-based essential and transferable lessons on groundwater supply projects and sustainable rural water provision, mainly for disperse rural communities.

***Keywords*—** Groundwater, Potable Water, Sustainability, Sustainable Management, South Africa

I. Introduction

ACCESS to safe drinking water continues to be one of the most complex challenges facing rural communities in Africa. As of 2000, the level of access to potable water in Africa was only 47% and about 320 million people still lack access to safe drinking water in Sub-Saharan Africa [1]. Over the 1990–2010 period, significant investments and initiatives were undertaken to improve access to safe drinking water – resulting in tangible improvements, with several countries achieving their Millennium Development Goal target of halving, by 2015, the proportion of people without sustainable access to safe drinking water [2]. It is notable that most nations have predominantly relied on groundwater resources to provide rural water supplies [3]. Globally, close to 1.5 billion people get their potable water supplies from groundwater sources), making groundwater the most extracted raw material, with withdrawals close to 600-1100km^3/year [4],[5].

A number of factors make groundwater a preferable option for rural water supply schemes. These factors include that groundwater: can be easily developed closer to homesteads; is generally of an acceptable quality with low contamination risk; is relatively cheap to develop [6], [7] is more reliable and drought-proof compared to surface water [8] and is less susceptible to seasonal and perennial fluctuations [9]. This makes groundwater more demand responsive in rural settings than surface water. However, in spite of the positive attributes and recognized potential to address rural water supply challenges, groundwater has not been positively considered by all communities as a water supply resource. This is despite recent increases in investments and development initiatives by development banks, national governments and donor agencies towards promoting its use in combating water supply challenges. Consequently, huge challenges still remain in rural Sub-Saharan Africa with respect to accessing potable water supplies. This is particularly so in dispersed low income rural communities where reticulated water schemes are difficult and often uneconomic to install.

This paper looks at how the perennial problem of poor rural water supplies can be addressed through groundwater supply solutions. In approach, the paper first reviews the challenges experienced by rural communities in accessing sustainable safe drinking water. The paper then looks at practical approaches to improve rural water supplies, with an emphasis on how groundwater can play a significant role. The paper concludes by showcasing a recent South African groundwater project, highlighting the application of groundwater solution in addressing perennial rural water challenges.

II. PURPOSE OF PAPER

This paper is based on a groundwater program implemented in the Free State Province, South Africa, to improve water supplies in rural and peri-urban areas. The paper intends to fulfil two objectives, namely:

- Highlighting the perennial and persistent challenges faced by rural communities in accessing sustainable fresh drinking water.
- Accentuating the importance of groundwater as a sustainable water source for dispersed rural communities, drawing lessons from a recent South African rural groundwater supply project.

J. Mutamba is with the Trans-Caledon Tunnel Authority, 265 West Avenue, Centurion, South Africa (email: jmutamba@tcta.co.za)

III. RURAL WATER SUPPLY OVERVIEW

Please submit your manuscript electronically for review as e-mail attachments.

A. Rural Water and the South African Water Context

Rural Africans have the lowest access to clean and sustainable water supply compared to other developing areas in the world [10]. At the turn of the millennium, an estimated 300 million Africans did not have access to safe drinking water – many of whom were resident in rural areas. With its mix of developed and underdeveloped regions, South Africa has about 3.5 million people without access to water supply, and an additional 5.4 million people who have some access that still has to be brought up to minimum standard requirements [11]. Notably, most of the water supply backlogs are also in rural areas.

Over the past few decades, potable rural water supply moved to the centre-stage globally, mainly driven by non-governmental organizations, national governments and development banks [12]. Key initiatives include the declaration, by the UN General Assembly, of 2003 as the International Year of Freshwater and the establishment, as part of the Millennium Development Goals, the target to reduce by half the number of people without access to safe drinking water by 2015. Sadly, these initiatives have met with a number of challenges resulting in rather mixed achievement of the set rural water supply targets.

B. South African Water Context

Since coming into office, after the first democratic elections of 1994, the post-apartheid government has taken considerable strides to improve its citizenry's access to safe drinking water, first by making water a basic human right enshrined in its national Constitution. Section 27 (1) of the South African Constitution states that "*everyone has the right to have access to sufficient water*." In addition, South Africa promulgated two Acts of Parliament (the Water Services Act 108 of 1997 and the National Water Act 36 0f 1998) giving effect to the constitutional provisions for governing and management of water services and water resources, respectively. Section 3(1) of the Water Services Act (WSA) provides that 'everyone has a right of access to basic water supply and basic sanitation".

Based on the WSA, the South African government established regulations defining the "basic water service supply standard" as:

"minimum quantity of potable water of 25 liters per person per day or 6 kiloliters of water per household per month –

- At a minimum flow rate of not less than 10 l//min.
- Within 200 meters of a household, and
- With effectiveness such that no consumer is without water supply for more than seven full days in any year".

In 1994, only 59% of South Africans had access to basic safe and clean drinking water, with the larger proportion of the backlog (3.9 million households) domiciled in the poor rural former homeland areas [13]. However, bolstered by an unequivocal constitutional mandate, and dedicated commitment to improving people's lives, South Africa improved its citizenry's access to water to 88% by 2008 [14] and to 94% by 2012 [13]. The remaining backlog of 6% translates to 700 000 households and is equivalent to about 3.5 million people, who, unfortunately, are mostly rural households [13].

It is important to note that South Africa's milestone of reducing massive backlogs of people without access to safe drinking water is being achieved in environments replete with huge and, often, insurmountable challenges. These challenges are not unique to South Africa as, on a broader scale, many nations encounter considerable obstacles in providing their citizens with safe drinking water, more particularly so in rural settings. When you submit your final version, after your paper has been accepted, prepare it in two-column format, including figures and tables.

C. Rural Water Supply Challenges and Supply Options

Progress towards universal access to safe drinking water in rural settings has been beset by a number of challenges worldwide. Some of the challenges encountered include: general water scarcity; continued deterioration of source water quality; complex stakeholder requirements; limited funding resources; as well as poor, and, at times non-existent, operation and maintenance. All these challenges lead to a general lack of access to water. At village level, a lack of access to water results in poor agricultural production; food insecurity and poor livelihoods; village 'water wars'; and conflicts among community members over competing priorities for water [15].

Notwithstanding the numerous challenges and severe implications associated with lack of access to water in rural communities, there are a number of workable options to improve rural water supplies. Traditionally, surface water supply options have been the preferred option. Other options include rainwater harvesting and groundwater supply. Groundwater supply, in particular, provides a more reliable and sustainable rural water supply option. However, in South Africa, groundwater has not been afforded sufficient attention and focus as a water supply option, having been managed separately from surface water [16].

D. Global Groundwater Use

Although groundwater boasts a number of admirable qualities as a water resource, it enjoys mixed levels of appreciation globally. In some areas, communities are predominantly dependent on groundwater (e.g. the African continent, India, Pakistan, and China) while in some areas the resource remains marginalized and under-utilized. On a broader scale, groundwater has been widely ignored, misunderstood or abused, as an essential source of water [17].

Over the past few decades, groundwater use has grown

exponentially [5], with agricultural irrigation being the dominant use [18]. For example, California Central Valley, USA, abstracts 4 km^3/yr to support agriculture irrigation and India abstracts 18 km^3/yr groundwater for agriculture [19]. It is estimated that between 600 km^3 and 1100km^3 of groundwater is extracted annually worldwide. These abstractions represent about 20% of global annual surface water withdrawals [20] and 8.2% of annually renewable groundwater resources [21]. Leading groundwater using nations include: China, India, the USA, Pakistan, Iran, and Bangladesh.

Worldwide, groundwater contributes about 20% of freshwater requirements [5], quite a significant proportion but with a lot of scope to increase given groundwater's storage capacity of 10 000 000 km^3 [22], [23]. It is noteworthy that groundwater accounts for about 50% of global drinking water requirements [10]. Africa is estimated to have 660 000 km^3 of groundwater reserve [24], [25]. This reserve is said to be significantly more than the annual renewable freshwater resources and freshwater stored in African lakes. Correspondingly, in the Sub-Saharan Africa, groundwater has been one of the most reliable sources of rural water supply [6]. Most of the African groundwater reserves are available in modest yields (0.1 to 0.3 ls^{-1}) and at accessible depths (of less than 50m below surface) – making the resource more favourable for rural rather than urban development [17].

Groundwater contributes more than 80% of North Africa's drinking water [23]. Similarly, 80% of rural African population (estimated to be 540 million people) relies on groundwater supplies [26].

E. South African Groundwater Use Patterns

South Africa is a dry country with a geology that largely precludes the development of high yielding regional aquifers. More than 90% of the country is underlain by indurated sedimentary and crystalline basement rocks with little or no primary porosity. Highly permeable zones can be developed in fractured zones. However, given the general low porosity and low rainfall pattern over much of the country, it follows that long-term sustainable borehole yields are mostly low.

Prior to the promulgation of the National Water Act (NWA), Act 36 of 1998, groundwater in South Africa was considered a private resource and was, therefore, managed as a separate entity to surface water [16]. However, the NWA, which grew out the National Water Policy of 1997, now form the cornerstone of groundwater governance in South Africa. The policy is built on the principles of social equity, economic efficiencies and environmental sustainability. Under the new policy and the country's new water resources strategy, groundwater forms an integral part of the national water resources framework. These policy documents accords all water, including groundwater, equal status. However, the full implementation of the strategy is yet to be concretized.

IV. STUDY AREA DESCRIPTION

The study area is located in the Free State, one of South Africa's nine provinces (Figure 1). The Free State province is centrally located and Bloemfontein as the provincial capital. The area endures hot, arid conditions which vary quite drastically from season to season. The weather typifies that of a high-lying inland area with rainy summers, frigid winters and a lot of sunshine. The Free State Province's rainfall pattern can best be described as seasonal, highly variable and at times unreliable [27], [28], [29], [30], [31].

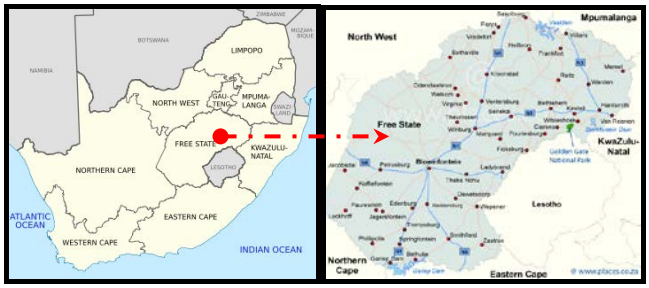


Figure 1: *Location of the Free State Province*

The Free State Province has, for some time, been facing perennial water supply challenges. In urban areas, the problems experienced range from natural water shortage, heightened water loss through aged aging and poorly maintained infrastructure, growing demand as well as storage limitations. The challenges are more pronounced in rural areas where households do not have piped water systems and thus struggle to gain access to safe drinking water. Cognizant of these challenges, the Department of Water Affairs, in collaboration with Trans-Caledon Tunnel Authority, initiated, planned, designed and implemented a groundwater development program for rural communities covering six provinces. This paper focuses on the Free State portion of the program and specifically on work conducted in the three municipalities of *Setsoto*, *Masilonyana*, and *Mangaung Metro*. These areas were selected as they were considered to be facing considerable water supply challenges.

V. THE FREE STATE GROUNDWATER PROGRAM

The Free State groundwater program was designed to provide clean, safe and sustainable water supply to previously disadvantaged rural communities who never had access to the precious resource. The project involved planning, designing, siting, drilling, testing (yield and quality), as well as equipping the boreholes. Where there were existing boreholes, the scope entailed rehabilitating dysfunctional boreholes following detailed infrastructure soundness assessment as well as yield and quality testing. The project was implemented over 18 months, starting in June 2011. Notably, the program was characterized by very stringent timeframes and budget against a very broad and ever expanding scope of work.

VI. PROGRAM OUTCOMES: LESSONS LEARNT

Across the three municipal jurisdictions, a total of thirteen boreholes were sited, drilled and fully equipped. Of the thirteen functional boreholes, ten were previously existing

dysfunctional boreholes, rehabilitated to full functionality. A mix of hand pumps, wind mills, electric and diesel-driven pumps were used to draw water from the boreholes. In total, the program provided safe and sustainable drinking water to about 220 households and an approximate equivalent population of 1 100 people. It is noteworthy that the new water supply schemes provided water to within 250m from family homesteads, whereas, previously, families had to walk for kilometres in search of water or relied on dirty water from contaminated local streams. Table 1 summarises the distribution of households and population impacted by the program, and Figures 2a and 2b show samples of the project images.

Table 1: *Outcomes of the Free State groundwater program*

Municipality	No of Boreholes	Yield Range [m^3/d]	Households Served	Population
Setsoto	3	43 – 86.4	50	250
Masilonyana	6	49 - 205	100	500
Mangaung	4	17.3 - 35	70	350
Total	13	17.3 - 205	220	1 100

(a)

(b)

Figure 2: *Images of Free State groundwater project works*

A. Program Lessons

A number of practical lessons were drawn from the Free State rural groundwater supply program, many of which are useful in global rural water supply project settings. Key lessons obtained from the project include:

Emergency interventions: Emergency interventions require dedicated funding and material resources, as well as sufficient time allocation. During the implementation of the Free State groundwater supply project, several scope changes were requested by the client, some of them significantly huge, but with no sufficient provision for corresponding resources. The original scope of work and budget had not provided sufficient resources for such scope variation.

Project timelines: When conceptualizing and planning for each project, project planners, engineers and managers should make sufficient provision for time to implement the project. In the given project, the original project duration was too short considering the magnitude and complexity of the work identified. It was observed that in a project, and right from the planning phase, it is essential to create a good balance among the competing constraints of scope, quality, schedule, budget, resources and risk in order to deliver a successful project. Further, the project was fast-tracked mainly for political objectives and targets – resulting in unrealistic timelines.

Integrated planning: Achieving sustainable rural water supply goes beyond mere building of pertinent infrastructure – but includes extensive strategic stakeholder engagement, post construction training, and raising awareness on the importance of regular operation and maintenance. Further, all key project partners should have congruity of purpose to ensure that their combined efforts are focused towards a common goal and thus amplify each other rather than pulling in different directions. All eventually a successful project, a significant amount of time and effort were spent addressing internal tensions rather than working on project progress – which created unnecessary tension.

Capacity building in local government: The groundwater program's success can be predicated mainly on two measures: the number of communities provided with sustainable water supply, and the extent to which the completed assets can be maintained. The second measure depends on the expertise and capacity with the local government institutions who received the completed boreholes (to operate and maintain the assets). It was observed that there is a paucity of requisite skills in the local municipalities to maintain the boreholes, the reason why many of the boreholes had to be rehabilitated in the first place.

Alignment of project expectations: It was observed that, in some instances, end-user expectations about the project were not well aligned with the project owners' expectations. Often, end-users held high expectations, for example hoping to get reticulated water supply systems or electrically-powered water

ISBN: 978-1-61804-224-8

supply systems in instances where the project offered hand-pumps. These misalignments in expectations can, at times, stir-up tensions on project sites and thus impact on project delivery. Such issues can best be addressed at project planning level through wider consultation and open and broad communication processes – processes which were not instituted in the current program.

VII. Conclusions and Recommendations

Accessing safe and sustainable water supplies continues to be a major challenge to rural communities and it is particularly so on the African continent and in the most remote centres thereof. However, carefully planned and implemented groundwater programs can provide significant relief to water planners and managers as well as to the recipient communities. It is noteworthy that rural groundwater programs also can face insurmountable challenges as the South African Free State groundwater supply program has shown. To ensure high chances of success in rural groundwater supply programs, the following few but easy to implement recommendations are proposed:

Improved background planning: It is recommended that more detailed background planning goes into future projects, particularly to improve understanding of the project scope in the specific project area. This can be achieved through improved collaborative liaison between the client department and water service authorities to identify critical areas and develop a commonly agreed prioritization. This approach has the impact of improving project execution efficiencies. For this happen, it is essential that water managing institutions are capacitated withy the planning, engineering and management skills for them to effectively roll out rural ater supply programs.

Realistic timeframes: Often projects have been initiated as urgent and strategic, resulting in very short implementation timeframes being allocated. The effect of such approach has been to solicit rushed approaches to the project with negative consequences at the end eroding the initial rushed gains. To avoid these effects, it is recommended that, in future, with improved background planning recommended above, care be taken to allocate realistic timeframes to such projects and fully experienced team in such kind of projects. Essential in this concept, is the separation of short term political imperatives from objective and practical technical planning requirements.

Community involvement to curb vandalism: Vandalism of infrastructure stands out to be the major concern in all the provinces. It is therefore recommended that the responsible department and water service authorities involve local communities in projects to ensure buy-in and build a sense of ownership of the infrastructure by the community. This will possibly reduce the level of vandalism.

Improve operation and maintenance: All water infrastructure should be operated well and be regularly maintained to improve its lifespan. Water service authorities need to invest a lot of effort and time and other resources to address the skills gaps in the operation and maintenance area.

Finally, to ensure universal access to water, it is recommended that countries continue to roll-out rural groundwater supply programs. Rural-focused groundwater supply programs are an important and commendable initiative, capable of providing redress to the inequities of the past and respite to the rural poor who, in most instances, have never had the privilege to access clean drinking water.

References

[1] World Health Organization & UNICEF. (2013). Progress on sanitation and drinking water – 2013 update. World Health Organization and UNICEF. France.

[2] UNICEF & WHO. (2012). Progress on drinking water and sanitation. 2012 update. UNICEF and World Health Organization, USA.

[3] Calow, R. & MacDonald, A. (2009). What will climate change mean for groundwater supply in Africa? Background Note. Overseas Development Institute.

[4] Foster, S. (2006). Groundwater sustainability issues and governance needs. Episodes 29 (4): 238 – 243.

[5] Kinzelbach, W., Bauer, P., Siegfried, T., & Brunner, P. (2003). Sustainable groundwater management – problems and tools. Episodes, Vol. 26 (4): 281 – 284.

[6] MacDonald, A. & Davies, J. (2002). A brief review of groundwater for rural water supply in Sub-Saharan Africa.

[7] Llamas, M. R. & Martinez-Santos, P. (2005). Intensive groundwater use: salient revolution and potential source of social conflicts. ASCE Journal of Water Resources Planning and Management, Vol. 131: 337 – 341.

[8] Siebert, S., Burke, J., Faures, J. M., Frenken, K., Hoogeveen, J., Doll, P. & Portmann, F. T. (2010). Groundwater use for irrigation – a global inventory. Hydrology and Earth System Sciences, Vol. 14: 1863 – 1880.

[9] UNESCO. (2004). Groundwater resources of the world and their use.

[10] United Nations. (2003). Water for people, water for life. UNESCO-WWAP, Paris.

[11] Kahinda, J. M., Taigbenu, A.E., & Boroto, J. R. (2007). Domestic rainwater harvesting to improve water supply in rural South Africa. Physics and Chemistry of the Earth, Vol. 32: 1050 – 1057.

[12] Gleitsmann, B. A., Kroma, M. M. & Steenhuis, T. (2007). Analysis of a rural water supply project in three communities in Mali: Participation and sustainability. Natural Resources Forum, Vol. 31: 142 – 150.

[13] Department of Water Affairs. (2012). Annual Report. 1 April 2011 – 31 March 2012. DWA, Pretoria.

[14] President Kgalema Motlhante. (2009). State of the nation address of the president of South Africa to the joint sitting of parliament". February 6, 2009, available at: http//www.pmg.org.za/briefing/20090206-state-nation-address, accessed 25 June 2013.

[15] Narayan, D. (1993). Focus on participation: Evidence from 121 rural water supply projects. UNDP-WB Water and Sanitation Program and Social Policy and Resettlement Division. Word Bank, Washington DC.

[16] Wright, K.A., & Xu, Y. (2000). A water balance approach to the sustainable management of groundwater in South Africa. WaterSA, Vol. 26(2): 167-170.

[17] Edmunds, W. M. (2012). Perspective: Limits to the availability of groundwater in Africa. Environmental Research Letters, Vol. 7: 1-3.

[18] Global Water Partnership. (2012). Groundwater resources and irrigated agriculture – making a beneficial relation more sustainable. GWP, Stockholm, Sweden.

[19] Powell, D. (2012). Satellites show groundwater dropping globally. Science News, Vol. 181 (1): 5-6.

[20] Döll, P. (2009). Vulnerability to the impact of climate change on renewable groundwater resources: a global-scale assessment. Environmental Research Letters, Vol. 4.

[21] Sharma, B.R. and K.G. Villholth (Eds), 2006. Groundwater Research and Management: Integrating Science into Management Decisions. Proceedings of IWMI-ITP-NIH International Workshop on: "Creating

Synergy between Groundwater Research and Management in South and Southeast Asia", Feb. 8-9, 2005, Roorkee, India. Groundwater Governance in Asia Series. International Water Management Institute, South Asia Regional Office, New Delhi, India,

[22] Postel, S. L., Daily, G. C., & Ehrlich, P. R. (1996). Human appropriation of renewable freshwater. Science, Vol. 271.

[23] Planet Earth. (2005). Groundwater – Reservoir for a thirsty planet? Planet Earth, Earth Sciences for Society, Norway.

[24] MacDonald, A.M., Bonsor, H.C., Dochartaigh, Taylor, R.G. (2012). Quantitative maps of groundwater resources in Africa. Environmental Research Letters, Vol. 7: 1-7.

[25] Wickham, C. (2012). Africa sitting on a sea of groundwater reserves. Business & Financial News.

[26] JMP. (2008). Global water supply and sanitation 2008 report. Joint Monitoring Programme WHO/UNICEF. Geneva: World Health Organization.

[27] Fauchereau, N., Trzaska, S., Rouault, M., Richard, Y. (2003). Rainfall variability and changes in Southern Africa during the 20th Century in the Global Warming context. Natural Hazards 29, 139–154.

[28] Usman, M.T., & Reason, C.J.C. (2004). Dry spell frequencies and their variability over southern Africa. Climate Research 26, 199–211.

[29] Reason, C.J.C., Hachigonta, S., Phaladi, R.F. (2005). Inter-annual variability in rainy season characteristics over the Limpopo region of Southern Africa. International Journal of Climatology 25, 1835–1853.

[30] Hachigonta, S., Reason, C.J.C., Tadross, M. (2008). An analysis of onset date and rainy season duration over Zambia. Theoretical and Applied Climatology 91, 229–243.

[31] Moeletsi E. (2010). Agroclimatological risk assessment of rainfed maize production for the Free State Province of South Africa. Ph.D. thesis. Agrometeorology, University of the Free State.

The Effect of Landscape Elements on the Satisfaction of the Low Income people in Egypt

Rania Rushdy Moussa

Abstract— The relation between landscape elements and human life has been the concern of many researchers in the past few years due to its importance. Many researches expressed their ideas in this field by different ways. Parks or landscape elements provides a multitude benefits for human's that can be categorized as economic, ecological, climatic, Public health and social benefits. The present research aims to examine the role of landscape elements which are presented in this research as parks and its effect on the quality of low income lives in Egyptian urban environments. It measures the quality of those low incomes in terms of 'human needs' and 'subjective well-being'. Relevant literature is reviewed and a theoretical framework is set accordingly. Hence, the study explores the impact of elements of parks upon subsistence, reproduction, security, affection, understanding, participation, leisure, spirituality, creativity, identity and freedom; set by the adopted model for 'human needs'. Then, it investigates the impact of elements of parks upon happiness, utility and welfare; identified by the undertaken framework of 'subjective well-being'.

Finally, the study concludes a full understanding of the impact of parks which represent the landscape elements and its effect on 'quality of life' of low income categories, as a synthesis of the findings from 'human needs' and 'subjective well-being'. This should open ways for policymakers, practitioners, researchers and the public to realize the potentials of landscape elements and parks towards improving the quality of life for low income people's and recognizing the aspired-for individual and social development in Egypt.

Keywords—Elements of Parks, Human Needs, Quality of Life (QOL), Subjective Well-Being.

I. INTRODUCTION

THE human relationship with the natural world is deeply intertwined with the human conscious and subconscious mind, which made this relationship difficult to analyze. Nonetheless, this relation has been the concern of many researchers in the past few years due to its significance and many researches expressed their ideas in this field by different ways such as references [9], [25], [26], [30], [31], [32], [33] & [35].

In recent years, there have been concerted attempts, particularly in the disciplines of ecology, biology, environmental psychology and psychiatry to empirically examine the human relationship with the natural world. Humans especially the low incomes are dependent on nature not only for material needs (food, water, shelter, etc) but also for psychological, emotional and spiritual needs [9], [30], [31], [32], [33], [34], [35] & [36].

The significance of landscape elements to the quality of life for low incomes is increasingly established. [32]. Quality of life (QOL) is defined as the "extent to which objective human needs are fulfilled in relation to personal or group perceptions of subjective well-being" [13]. Diverse "objective" and "subjective" indicators across a range of disciplines and scales and recent work on subjective well-being (SWB) surveys and the psychology of happiness have spurred interest. The understanding, measurement and improvement of human experience have been major goals for individuals, researchers, communities and governments. The overall assessment of human experience has been commonly expressed by the term (QOL) across multiple disciplines including psychology, medicine, economics, environmental science and sociology [13].

Recent research on QOL has focused on two basic methodologies of measurement. The first of these methods utilizes quantifiable social or economic indicators to reflect the extent to which human needs are met. The other looks at self reported levels of happiness, pleasure, fulfillment and the like; it has been termed "subjective well-being" (SWB) [28] & [29].

A. Elements of parks:

In this study, the landscape design is not the primary scope, we use the elements of landscape to measure the relations between landscape elements and its effect on level of satisfaction of low income people. elements of landscape are discussed in detail in [14], [15], [16], [17], [18], [19], [20], [21], [22] and others.

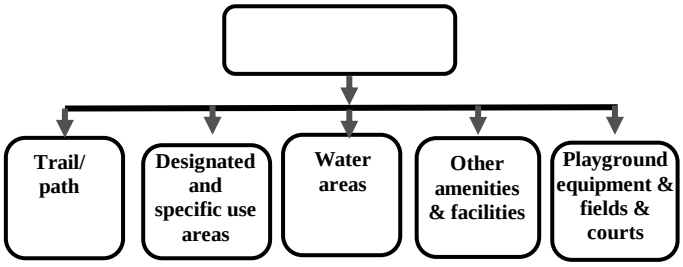


Fig. 1 Elements of parks [20]

The framework of the landscape elements (shown in fig. 1) used in this study was adapted from reference [20] framework, which has divided the landscape elements into five categories as follows:

1. Trail/Path

Trails, path, or footpath networks are important elements in the landscape, allowing people to enjoy the landscape, whether this landscape was a natural one such as mountains, forests, coastal or inland waterways or artificial such as parks and farms. Landscapes can be destroyed by poorly constructed paths, while well designed pathways and trails can add a great value to the landscape and allow people to experience it [14], [16].

2. Designated and Specific Use Areas

These areas include: open space, meadow, wooded area, picnic area, camping site, shelter/pavilion/gazebo, entertainment venue/stage, area surrounding park, wildlife or pet area and parking lot.

Public parks and open spaces helped people to transform from passive spectators to active participants. Specific use areas such as parks have a major role in accomplishing three main objectives: provide health, pleasure, art, and a powerful influence to the city.

Urban green spaces and specific use areas, especially in parks increase the quality of life by presenting several recreational experiences. Benefits and performances of green spaces are measured by the user's level of satisfaction [17], [22].

3. Water Areas

Water Water features in parks include lakes, ponds, fountains, fishing area, stream/creek, wetland, reflective pools and waterfall.

Water provides visual enjoyment, improves the micro-climate, creates focal points, irrigation reservoirs and native habitats and creates recreational opportunities [15], [21].

4. Other Amenities and Facilities

Site amenities and facilities have a positive effect on the performance of the site; they includes benches, trash receptacles, tables, vending machines, flag poles, telephone booths, bus shelters, kiosks, mail boxes, sculptures, walls, fences, monuments, memorials, gazebos, drinking fountains, bike racks and picnic shelters.

Arts and sculptures play a prominent role in landscape architecture of public spaces and their usual job is the representation of different expressions of a cultural relationship between man and site as well as man and nature [20].

5. Playground Equipment and Fields and Courts

Playgrounds, fields and courts includes: play-set, imaginary play structure, ground surface, things to swing/hang from, things to climb on/up/through, things to stand or walk on, swings and things to slide down, etc.

They are to get people out from behind glass and walls. They provide a place where children are able to play in shaded, bigger and safe places. Playgrounds, fields and courts help neighbors in knowing each other, coming together, creating relationships and building a sense of community [19].

B. Quality of life:

The quality of life (QOL) can be described and measured in individual terms; an approach where subjects or persons create their own definitions which may be more appropriate measures [37]. Researchers from different fields started to study the quality of life (QOL) since 1930's [38]. They tried to identify the components and parameters of QOL and compared various geographical areas such as cities, states and nations by means of QOL indices that they developed such as [2], [3], [4], [5] & [6]. In addition to the researchers, international organizations such as UNDP (1994), UN and Overseas Development Council (1996) developed their own measures for the QOL that is why we have many measurements and parameters that can define the QOL, That concludes different results from studies on the QOL due to the differences in the chosen sets of variables, aspects and measurements [9]. As shown in table [1] it is difficult to find agreement on the aspect of QOL in the literature. Nevertheless, there are common aspects such as Social, Economic and Environmental. QOL aspects are rarely measured by the same units. Sometimes the names of the aspects can be misleading in many cases. Reference [9] stated that: "Some of those aspects are measured with irrelevant indicators such as reference [38] criticized, as in reference [2] the author had measured his social aspect by fifty four indicators which are common between political and economic aspects and those indicators are common with the social component, which leads to double counting, and to bias".

TABLE I
THE PARAMETERS OR FACTORS THAT AFFECT THE QUALITY OF LIFE (QOL)
SOURCE: THIS TABLE HAS BEEN ADAPTED FROM QOL ASPECTS IN LITERATURE

Source	Aspects
[2]	(1)Economic, (2)Political, (3)Environmental, (4)Social and (5) health & educational.
[3]	(1)Climate, (2)Housing, (3)Health care & environment, (4)Crime ,(5)Transportation, (6)Education, (7)Arts, (8)Recreation, (9)Economics

[4], [5]	(1)Precipitation, (2)humidity, (3)heating degree days, (4)cooling degree days, (5)wind speed, (6)sunshine, (7)coast, (8)violent crime, (9)teacher pupil ratio, (10)visibility, (11)total suspended particulates, (12)NPDES effluent discharges, (13) landfill waste, (14)superfund sites, (15)treatment, storage and disposal sites, (16)central city.
[6]	(1)Public safety, (2)food cost, (3)living space, (4)housing standard, (5)communication, (6)education, (7)public health, (8)peace and quiet, (9)traffic flow, (10)clean air
[7]	(1)Quality of physical environment, (2)Quality of social environment, (3)Quality of economic environment, (4)Quality of transportation & communication.
[8]	(1)Transportation factor, (2)Noise in the urban space, (3)Air pollution in the urban space, (4)built density, open space and environmental quality in residential neighborhoods, (5)Environmental evaluation system for buildings and spaces, (6)Esthetics and the environment, (7)Public participation and the urban environment.
[9]	(1) Environmental, (2) Economic, (3) Social.

Table [1] views different frameworks of QOL that have been used through history. The table shows repetition for Environmental, Economic and Social aspects. From year 1988 to 2005 the QOL frameworks have been more detailed than before. It starts to presents the aspects in new forms that manly considered the human as an important aspect. While since 2005 the theorists have disagreed in the form of QOL framework, some theorists have returned to view Environmental, Social, Economic aspects as the most important aspects in life in order to improve the human life quality. While others continued the pass of 19th century theorists and start to describe the aspects as much as they can, to prevent conflict and overlapping of information. A large number of scales and tests have been devised to measure the QOL. QOL measures vary widely in concept, construction and content; therefore, they cannot always be compared directly with each other [1]. Both objective and subjective indicators are used as measures of the QOL. Objective measures have the advantage of not being subject to observer error, but they are insensitive to the feelings of the subject [10]. These measures have been expressed regarding the reliability of some measures, for example: crime rates, housing density and income [11]. Subjective parameters, such as job satisfaction, happiness, utility, welfare for individuals or group and perceptions of health and morale involve subjects being asked to make judgments about their lives; this is the strength of subjective measures. As references [12] has stated, "people's perceptions, however uninformed they may be, are real and people act on the basis of them".

In this research, reference [13] framework of the QOL has been adopted because it is the most suitable framework to this research, it considers the human needs and well-being as the most important contributors in human QOL and that is the one of the objectives of this research. Reference [13] defined QOL as measuring human needs with subjective well-being. QOL is proposed as a multi-scale, multi-dimensional concept that contains interacting objective and subjective elements. Since that reference [13] were studying the relation between QOL and opportunity, which is out of the scope of this research, an adaptation has been made where only the framework of QOL has been used as shown in figure [2].

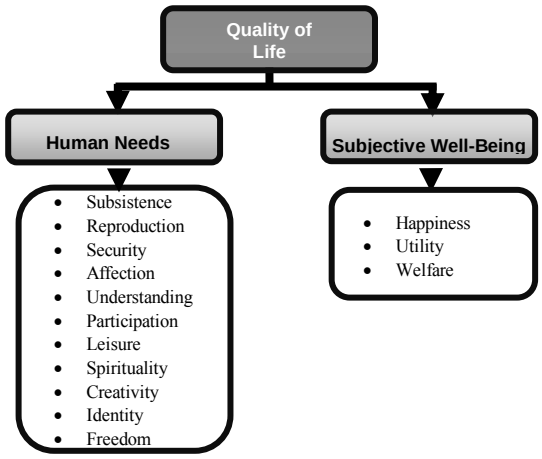


Fig 2 The adapted model for studying Quality of Life (QOL)

II. Procedure

A. Study Area:

Al-Azhar Park was chosen to be the study area of this research according to some criteria and these criteria were as the following:

Has been construct in the last 10 years to serve the quality of life of this generation and to fill their needs. The main purpose of constructing this park is to improve and enhance the quality of life for the surrounded residents and it is surrounded by poor districts. It is surrounded by in low income areas, which serves the scope of this research by studding the effect of this park on the residents QOL. Although the park is surrounded by low income areas but it serves different economic levels.

Al-Azhar Park is one of the largest parks in Cairo and it is surrounded by several historical places as shown in fig 3. The aim of this project is to design a huge Park to revitalise this heritage in a manner which makes it a stimulus for social and economic development.

Fig. 3 The setting of the Al-Azhar Park in relation to the surrounding districts

Al-Azhar Park is located in Darb Al-Ahmar district in the core of Fatimid Cairo which was established in the 10th century AD. It is surrounded by the most significant historic districts of Islamic Cairo as shown in fig. 4. From the north, it is surrounded by significant historic districts of Islamic Cairo as Al-Hussein, El-Mosky, Khan El-Khalili, El-Darasa and Al-Gamalia. To the east, are the Mamluk "City of the Dead", Salah Salem Street (one of the main streets of Cairo), and Manshiyat Naser district. To the south, there are the Sultan Hassan Mosque and its surroundings, as well as the Ayyubid Citadel. Finally, to the west there is the Fatimid city and its extension to Bab El-Wazeer and Darb Al-Ahmar district with their wealth of mosques, madrasas and mausolea. The coordinates of Al-Azhar Park are 30°2'27"N and 31°15'53"E. The total area of the Al-Azhar Park is 30 hectare (74 acre) [23].

The district of Darb Al-Ahmar is well known as an impoverished residential/commercial district. On the other hand, it features one of the richest concentrations of Islamic art and architecture in Cairo. The current urban character of the district is an organic tissue of narrow alleys, lined with shacks, strewn with garbage, and prowled by drug dealers. Darb Al-Ahmar was until recently one of this city's most disreputable slums with about 30 square centimetres of green space per resident [9].

B. Components of Al-Azhar Park:

The Park is held together by a formal axis or spine which is tied together along its entire length with a water channel providing an additional and traditional theme from Islamic gardens. Water fountains and pools are dispersed and lead ultimately to the most free form of the lake in the south meadow. Gardens and pavilions in the classical Islamic tradition, surrounded by geometrically planted orchards which enhance the arrival point on the edge of a lake. The central pathway accompany's alleyways and series of formal gardens and anchored at each end by the hilltop restaurant and lakeside cafe, which act as internal landmarks. A network of informal pathways surrounds the more formal areas and leads through all levels and corners of the site [24]. All these components of the park are shown in fig. 4.

Fig. 4 Master Plan of the Al-Azhar Park and its components [23]

1. Lakeside Cafe
2. Hilltop Restaurant
3. Ayyubid Cafe
4. Royal Palm Promenade
5. The Mountain and telescope
6. Children's Play Area
7. Park Entrance
8. Ayyubid Historical Wall
9. Lake

C. Procedures

The survey was conducted between September and November 2013. Part of the survey was made inside Al-Azhar Park while the other part was done in Darb Al-Ahmar district. A total of 260 participants were voluntary willing to participate in the survey. 170 participants participated through the survey in Al-Azhar Park while 90 participants participated during the survey in Darb Al-Ahmar district.

The distribution of the participant's social and demographic characteristics, such as gender, age, marital status and education level are shown in Table II.

TABLE II
SOCIAL AND DEMOGRAPHIC CHARACTERISTICS OF PARTICIPANTS IN THE STUDY

GENDER		**AGE**		**EDUCATION**	
Type	Percentage	Range	Percentage	Education level	Percentage
Male	53%	*Below 20*	12.12%	*Uneducated*	36.36%
Female	47%	*20-29*	27.27%	*Basic*	30.30%
		30-39	12.12%	*Secondary*	3.030%
		40-49	15.16%	*Technical Education*	12.13%
		Above 50	33.33%	*Higher Education*	18.18%

People were approached in the park and were informed about the survey's objective and the procedures to answer the questions. Those willing to participate voluntarily were given the questions and were invited to fill it in during their stay in the area, so that the answers would reflect their immediate experiences. Each question was described to them before starting to answer the question in order to guarantee that they understood each question.the questionnaire were distributed

on both weekdays and weekends, in different hours of the day and in different parts of the parks relevant to the parts that fit the elements of parks.

Statistical software SPSS 17.0 was used to conduct statistical analysis on each data subset to extract the major factors of the corresponding scale by employing the Mean vale, standard deviation and the ANOVA table. After that, all the data were statistically analyzed using SPSS program in order to measure the effect of elements of parks on the 'quality of life' in terms of 'human needs' and 'subjective well-being'.

III. Results

The questionnaire was a self-report which measures behaviors, background information and psychological trails concerning their life satisfaction toward landscape . The data of all 260 participants was complete and was used in the analysis. The whole data set was divided into 65 data subsets, corresponding to 65 variables which occurred from observing the relation between each elements of the park with the aspects of quality of life (5 landscape elements into 13 QOL aspects).

Statistical software SPSS 17 was used to analyze the data and the following charts revealed the relation between each landscape element concerning all the QOL aspects. In order to understand the significance of the elements on the QOL aspects it was decided to choose the aspect that the participants have stated it more than 5 to be the highest satisfaction aspects which satisfy park visitors the. The total number of responses was 7 and 4 is the moderate response, so 5 responses were chosen which was more than the moderate to prove that this aspect satisfied the park visitors in this specific places. 4 to 4.9 were chosen to be the moderate value, while less than 4 responses were the lowest satisfaction aspects which satisfied the visitors. In the figures below the significant aspects are above the thick blue line, while the non-significant aspects are below the thin blue line.

The following tables and charts summarize the results of the study, revealing mean value between the landscape elements and QOL aspects in general.

During the survey it was noticed that most of the Al-Azhar park visitors were low income visitors and that was due to its location since that the Al-Azhar park is surrounded by low income neighborhoods and districts, the most important issue is that the low income visitors were satisfied with everything in the park while the high income visitors weren't satisfy with several things.

As soon as the research started, it was very obvious the location of each income level categories, the high income visitors were located in the cafeterias and the expensive places while the low income visitors were all over the park sitting on the grass or walking between the trees or sitting in the free benches. When the survey started it was notices that there is a strong relationship between income and human satisfaction as shown in the next few figures [6] to [10].

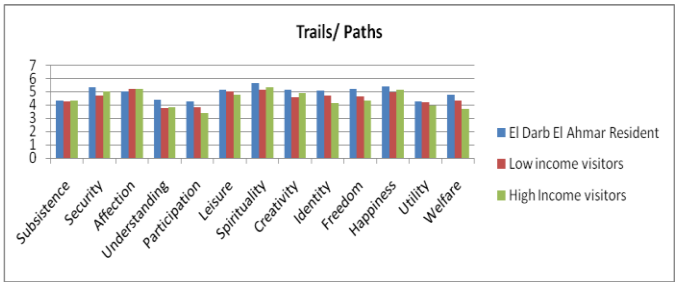


Fig [5] different values of Mean in Trails and pathways due to the visitors level of income

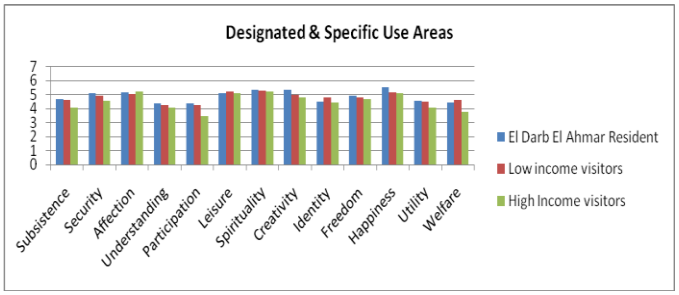


Fig [6] different values of Mean in Designated & Specific Use Areas due to the visitors level of income

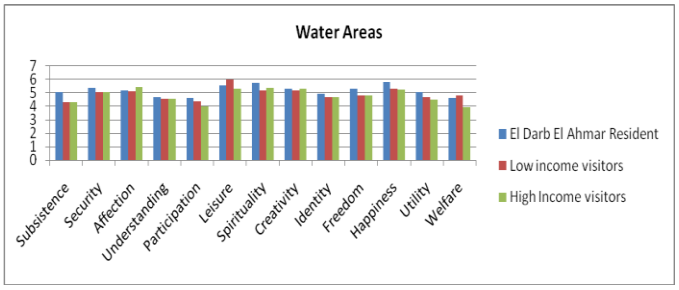


Fig [7] different values of Mean in Water Areas due to the visitors level of income

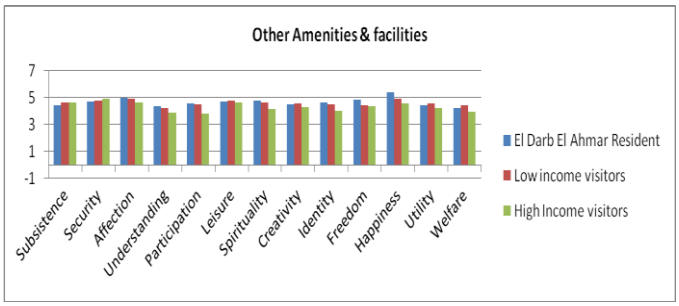


Fig [8] different values of Mean in Other Amenities & facilities due to the visitors level of income

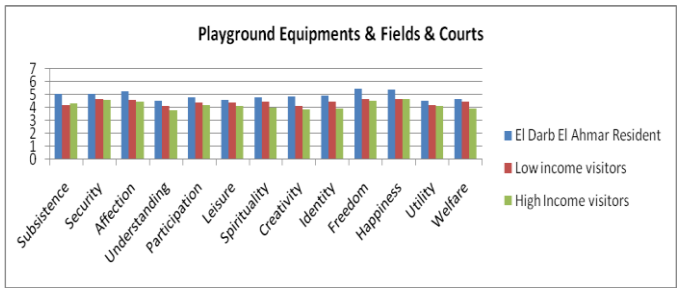


Fig [9] different values of Mean in Playground Equipments & Fields & Courts due to the visitors level of income

The results of the mean value revealed that the water areas were the places which satisfying most numbers of QOL aspects of the visitors. The second places were the open green spaces and trials/ pathways which are surrounded by green views and green spaces as shown in above figures.

IV. Discussion & Conclusion

The case study survey shows that people has a lot of fun in Al-Azhar park and that's why the level of happiness is very high in all the elements of parks which represent all the different places in Al-Azhar park, on the other hand people didn't feel that there is a welfare or opportunity to learn anything Al-Azhar park as well as they didn't feel that there is a lot of places or activities that help them to participate in it or to help them to be introduced in new people except in the playgrounds Equipments & Fields & Courts which represent the children's area in the park and some people see that the water areas such as the fountains and the lake provide an opportunity to learn new things.

The survey apparently shows a strong relation between walking and Spirituality and that appeared in the results, as we can see that there is a strong relation between Spirituality and Trails/path and Water Areas.

The substantive conclusion of this study is that, on average, respondents perception of QOL of their district was enhanced due to the advent of the Al-Azhar Park. This project provided a high opportunity of finding satisfactory jobs, adequate infrastructure and municipal services and increased commercial values that contribute to their income (Aga kan company). Thus, the city planners and municipal authorities should place the most emphasis on such projects in similar areas. This finding is consistent with the research hypothesis. Of course, some of the attributes cannot easily be manipulated, but this study indicates the priorities to allocate resources to improve the QOL in similar districts of the old core of Cairo.

A strong relationship has been seen in this research between income and human satisfaction. The more human poverty occurs the more satisfaction occurs. The Al-Azhar Park was designed to be a luxurious place although it located in a low income district and that's why most of the residents of Darb Al-Ahmar district has saw that the Al-Azhar Park is satisfying all their needs because they didn't see any other place that can satisfy all their needs. When we compare between the responses of Darb Al-Ahmar Resident, Low income visitors and High Income visitors we found that the residents and the low income visitors has more human satisfaction than the high income visitors.

When we take a closely look on the results we can see that there is a strong relationship between income and human satisfaction. Residents of higher socio-economic status also use or value urban nature areas to a greater degree than those of lower means. The socio-economic differences, however, may be a reflection of how richer people use their resources rather than an expression of differential preferences, benefits, or desires [35].The more human poverty occurs the more satisfaction occurs. The Al-Azhar Park was designed to be a luxurious place although it located in a low income district and that's why most of the residents of Darb Al-Ahmar district has saw that the Al-Azhar Park is satisfying all their needs because they didn't see any other place that can satisfy all their needs. When we compare between the responses of Darb Al-Ahmar Resident, Low income visitors and High Income visitors we found that the residents and the low income visitors has more human satisfaction than the high income visitors.

V. References

[1] M. Farquhar, Elderly people's definitions of quality of life. Britain, Elsevier Science Ltd Soc. Sci. Med. 1995, Vol. 41, No. 10, pp. 1439-1446.

[2] B.C. Liu, Quality of Life Indicators in US Metropolitan Areas: A Statistical Analysis. Praeger, New York. (1976).

[3] R. Boyer, and D. Savageau, Places Rated Almanac. Rand McNelly, Chicago. 1981.

[4] G.C. Blomquist, M.C. Berger, and J.P. Hoehn,. New estimates of quality of life in urban areas. American Economic. 1988. Review 78 (1), 89-107.

[5] M.E. Stover, and C.L. Leven, Methodological issues in the determination of the quality of life in urban areas. Urban Studies 1992. 29 (5), 737±754.

[6] A.J.M. Sufian, A multivariate analysis of the determinants of urban quality of life in the worldÕs largest metropolitan areas. Urban Studies. 1993. 30 (8), 1319±1329.

[7] B. Ulengin, F. Ulengin, and U. Guvenc, A multidimensional approach to urban quality of life: The case of Istanbul, 'European Journal of Operational Research' 2001, Volume 130, pp 361-374.

[8] I. Kimhi, Urban Environ mental Quality. The Jerusalem Institute for Israel Studies, The Center for Environmental Policy. 2005.

[9] A. Mahmoud, and R. Rushdy, The Role of Park Planning in Enhancing the Quality of Urban Environments. England, 2nd international Conference on whole life urban sustainability and its assessment, 2009. Loughborough University.

[10] M.J. Denham, Assessment of quality of life. In Care of the Long-stay Patient (Edited by Denham M. J.). Croom Helm, Beckenham. 1983.

[11] P. Townsend, and D. Gordon, Unfinished statistical business on low incomes? A review of new proposals by the Department of Social Security for the production of public information on poverty. University of Bristol, Report 3, Statistical Monitoring Unit Series. 1992.

[12] D. L. Abrams, Analysis of a life-satisfaction index. J. Gerontol. 1976. 24, 470.

[13] Costanza, R., Fisher, B., Ali, S., Beer, C., Bond, L., Boumans, R., Danigelis, N.L., Dickinson, J., Elliott, C., Farley, J., Gayer, D.E., Glenn, L.M., Hudspeth, T., Mahoney, D., McCahill, L., McIntosh, B., Reed, B., Rizvi, S.A.T., Rizzo, D.M., Simpatico, T. and Snapp, R. (2007). Quality of life: An approach integrating opportunities, human needs, and subjective well-being. Elsevier B.V., Ecological Economics 61 (2007) 267–276.

[14] C.I. Ferris, Recreation and the Landscape: Providing Trails – A Consideration of the Challenges Presented in Delivering Trail Networks for Recreation. Irish National Landscape Conference 2009.

[15] S.K. Hong, N. Nakagoshi, B.J. Fu, and Y. Morimoto, Landscape Ecological Applications in Man-Influenced Areas: Linking Man and Nature Systems, chapter 30: Linking Man and Nature Systems, 505–523. Springer Science+ Business Media B.V. 2008.

[16] L.M. Johnson, Trail of Story, Traveller's Path. Canada, AU Press, 2010. Athabasca University.

[17] H. Muderrisoglu, D. Oğuz, and N. Sensoy, An evaluation of green areas from the point of user satisfaction in Ankara, Turkey: Gap analyses method. Journal of Agricultural Research 2010. Vol. 5 (10), pp. 1036-1042, ISSN 1991-637X.

[18] M.E. Portman Zoning design for cross-border marine protected areas: The Red Sea Marine Peace Park case study. Elsevier, Ocean & Coastal Management 50, 2007. 499–522.

[19] T. Prow, The Power of Trees. The Illinois Steward, 1999. Volume 7 Issue 4.

[20] B.E. Saelens, L.D.Frank, C. Auffrey, R.C. Whitaker, H.L. Burdette, and N. Colabianchi, Measuring Physical Environments of Parks and Playgrounds: EAPRS Instrument Development and Inter-Rater Reliability. Journal of Physical Activity and Health 2006, 3, Suppl 1, S190-S207.

[21] H. Sienkowska, Water in the landscape of a town using the example of Gdansk and Gdansk conurbation. Hydrological Processes and Water Management in Urban Areas, IAHS Publ. no. 198, 1990.

[22] Y. Sirneoforidis, On Landscape and Open Spaces. Greece, Arch. & Comport. 1 Arch. & Behav. 1993. Vol. 9, no. 3, p. 321 – 327.

[23] Al- Azhar park Official website. Al-Azhar park master plan. Available from: http://www.alazharpark.com/ [1/4/2011].

[24] AEC, World Expo & Conferences Online Terms and Legal. (2009). The Azhar Park Project. Available from: http://www.iaandb.in/projects/landscape/azhar-park-project?search_key=sea+level&content_type=All&base_path=%2Fsearch%2Fnode%2F [1/6/2011].

[25] L. Tyrväinen, P. Pauleit, K. Seeland, and S. de Vries, Urban Forests and Trees: Chapter 4 Benefits and Uses of Urban Forests and Trees. Netherlands: Springer. 2005.

[26] Kaplan, R. and Kaplan, S. (1989). The Experience of Nature: A Psychological Perspective. New York, Cambridge University Press.

[27] Kruger, J. (2008). Parks, Recreation, and Public Health Collaborative. Atlanta, Environmental Health Insights 2008:2 123–125.

[28] Diener, E. and Lucas, R. (1999). Personality and subjective well-being. In: Kahneman, D., Diener, E. and Schwarz, N. (Eds.), Well-Being: The Foundations of Hedonic Psychology. Russell Sage Foundation, New York, pp. 213–229.

[29] Easterlin, R.A. (2003). Explaining happiness. Proc. Natl. Acad. Sci.100, 11176–11183.

[30] Dwyer, J., McPherson, E., Schroeder, H. and Rowntree, R. (1992). Assessing the benefits and costs of the urban forest. Journal of Arboriculture 18(5).

[31] Dyck, B. (2003). Benefits of Planted Forests: Social, Ecological and Economic. Wellington, New Zealand: Science & Technology Broker, PO Box 11236 Palm Beach.

[32] Sherer, P.M. (2003). Report: The benefits of parks: why America needs more city parks and open space. San Francisco: Parks for people.

[33] Wolf, K.L. (2004). Public Value of Nature: Economics of Urban Trees, Parks and Open Space. Edmond, 2004. Design with Spirit: Proceedings of the 35th Annual Conference of the Environmental Design Research Association.

[34] Ferraro, P.J. (2008). Protected Areas and Human Well-Being. Economics and Conservation in the Tropics: A Strategic Dialogue.

[35] Matsuoka, R.H. and Kaplan R. (2008) People needs in the urban landscape: Analysis of Landscape And Urban Planning contributions. Landscape and Urban Planning 84 (2008) 7–19.

[36] Galay, K. (2010). Time Use and Happiness. Gross National Happiness, the centre for Bhutan studies.

[37] Caiman, K.C. (1984). Quality of life in cancer patients—an hypothesis. J. Med. Ethics 10, 1551.

[38] Wish, N.B. (1986). Are we really measuring the quality of life? Well-being has subjective dimensions, as well as objective ones. American Journal of Economics and Sociology 45 (1), 93±99.

Prediction of Atterberg Limits via ANN and ANFIS: a Comparison

Muhammad Mukhlisin and Aini Sharina Binti Abd Rahman

***Abstract*—**In this study, Artificial Neural Network (ANN) and Adaptive Neuro-Fuzzy Inference Systems (ANFIS) methods are used to predict the values of three Atterberg limits: liquid limit, plastic limit, and plasticity index. The main objective was to analyze the predictive ability of the two models by comparing the produced Atterberg limit values with actual data sets in order to identify which method was more accurate and reliable. A total of 54 soil samples were taken across Peninsular Malaysia, with these samples then tested for different parameters including grain size distribution, liquid limit, plastic limit, and plasticity index. The input parameter used was grain size distribution, i.e., the percentage of sand, clay and silt, while the output was the predicted values of liquid limit, plastic limit and plasticity index. Actual and forecasted Atterberg limit data derived via the ANN and ANFIS methods were then compared based on R2 and RMSE values. The ANFIS model produced more accurate results than the ANN model in terms of liquid limit and plasticity index, but not plastic limit. Analysis of RMSE values also showed the ANFIS model to perform better than the ANN model in predicting the Atterberg limits.

***Keywords*—**Atterberg limit, Artificial Neural Network (ANN), Adaptive Neuro-Fuzzy Inference System (ANFIS), liquid limit, plastic limit, plasticity index, grain size distribution.

I. Introduction

Soil characteristics such as moisture content, Atterberg limits, specific gravity and grain size distribution strongly correlate with soil shear strength parameters. These features are also important for determining suitability of land use. Soil and underlying rock texture must first be determined in order to identify the stability of the soil, with a higher percentage of particles present in the ground or clay soil indicative of higher strength [1]. Atterberg limit tests are widely employed in the early stages of large-scale construction projects to ensure that the land has the right amount of shear strength and contraction under different moisture content values.

Atterberg limits can be used to distinguish between silt and clay, as well as between different types of silt and clay. Soils may appear in one of four states, namely solid, semi-solid, plastic and liquid, depending on water content. In each case, soil consistency and behavior varies (as does the nature of appropriate engineering). The boundary between each state can therefore be determined based on changes in soil behavior. Clay and silt react with water, changing in size and thus varying in shear strength. A large plasticity index value is indicative of low shear strength. The presence of excess soil water increases the load on the ground and at the same time destroys cohesion and reduces friction between soil particles. Previous studies have identified a linear relationship between a soil's liquid limit and percentage of the clay fraction. Research undertaken in Osaka Bay and Pusan using particle size distribution curves showed that a high clay fraction percentage is associated with a higher liquid limit value [2]. The latter authors also stated that the relationship between liquid limit and particle size distributions is not only determined by the size of the soil particles, but also by the thickness of the water layer absorbed by the solid particles.

Recently, significant and rapid progress has been made in the fields of non-linear pattern recognition and system theory using artificial neural networks (ANNs). ANNs have been employed successfully in many geotechnical engineering projects, including forecasting soil organic matter content, underground tunnel design, and many others. Perhaps the most successful application of ANNs in geotechnical engineering is the prediction of driven pile capacity and soil behavior [3]. Meanwhile, the adaptive neuro-fuzzy inference system (ANFIS) has established itself as one of the most popular modeling techniques in the fields of control systems, expert systems and the modeling of complex systems. In hydrology, Chang & Chang [4] used ANFIS to build a prediction model for reservoir management. Elsewhere, ANFIS has been applied successfully and has provided high accuracy and reliability in forecasting reservoir water levels [5]. As artificial intelligence techniques, ANFIS and ANN have frequently been used in the last decade due to their flexibility in modeling non-linear processes such as rainfall-runoff [6].

ANNs provide a method with which to characterize synthetic neurons in order to solve complex problems in the same manner as the human brain. Each model consists of several groups of artificial neurons or nodes, processing information using an interconnected approach to solve a specific problem. ANNs use data samples rather than entire data sets to arrive at solutions, which saves both time and money. Commonly, neural networks are adjusted or trained so that a particular input leads to a specific target output. ANNs are also typically used as random function approximation

This work was supported in part by the Ministry of Higher Education (MOHE) of Malaysia.

Muhammad Mukhlisin, Department of Civil and Structural Engineering, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia, 43600, Bangi, Selangor, Malaysia; and Department of Civil Engineering, Polytechnic Negeri Semarang, Jl. Prof. Sudarto, SH., Tembalang, Semarang, 50275, Indonesia. (Correspondence should be addressed to Muhammad Mukhlisin, mmukhlis2@yahoo.com).

Sharina Binti Abd Rahman, Department of Civil and Structural Engineering, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia, 43600, Bangi, Selangor, Malaysia.

tools, helping to estimate the most cost-effective and ideal methods with which to arrive at solutions whilst defining computing functions or distributions. For example, Goh et al. [7] employed ANNs to model the relationship between the relative density and cone resistance of the cone penetration test (CPT) for sand. The ANN models produced correlation coefficients as high as 0.97 and 0.91 for training and test data, respectively, suggesting that the neural networks succeeded in creating a non-linear model of the relationship between CPT cone resistance and other parameters. ANNs have also been used successfully in a variety of projects, including earth-retaining structures, structure settlement, slope stability, the design of tunnels and underground openings, liquefaction, soil permeability and hydraulic conductivity, soil compaction, soil swelling, and soil classification [1].

An adaptive neuro-fuzzy inference system (ANFIS) is a network based on a Takagi-Sugeno fuzzy inference system. Fuzzy inference systems (FIS) combine both neural networks and fuzzy systems, potentially providing the benefits and abilities of both in a single network [8]. ANFIS is considered a universal estimator as it uses a set of 'if-then' fuzzy system rules that provide the ability to estimate a non-linear function. Based on a given input/output data set, the ANFIS function constructs a fuzzy inference system (FIS) whose membership function parameters are tuned (adjusted) using either a back propagation algorithm alone or in combination with a least squares method. This adjustment allows fuzzy systems to learn from the data they are modeling [9].

Although the values of Atterberg limits such as liquid limit, plastic limit and plasticity index can be determined via laboratory experiments, the process can be very time consuming, especially if there are a lot of samples to be tested. According to Budhu [10], using a Casagrande device to carry out the liquid limit test has many shortcomings. For instance, a very small device may produce a huge error, while the sensitivity of the operator handling the tools should also be taken into consideration. Previous studies involving the prediction of grain size distribution were conducted by Berbenni et al. [11] and Rasmin [3], whereas Fukuda et al. [2] examined the relationship between liquid limit and soil particle size. However, as yet no study has explored the prediction of Atterberg limits using grain size distribution. In order to overcome the complexity and diversity of soil behavior problems, especially in terms of geotechnical characteristics, the establishment of an appropriate engineering design model is required. Such a precise yet simple model could be used to predict Atterberg limit values without the need for laboratory tests.

In this paper, the prediction of Atterberg limits will be analyzed based on grain size distributions modeled in terms of sand, silt and clay percentages. A comparison of the predictive ability of ANN and ANFIS models will be conducted. A further objective of training either an ANN or ANFIS as a prediction model is to generalize, with the network output approximating target values using input values not in the training set. By comparing the results of these two methods, their respective advantages and disadvantages will be identified and discussed.

II. Materials and Methods

A. Study Area

Soil samples were taken based on the occurrence of debris flow events across Peninsular Malaysia, as recorded in Table 1. Figure 1 presents the locations of the grain size distribution samples used in the study. The sampling region can effectively be divided into two areas, comprising the states of Pahang and Perak (Area 1) and Johor (Area 2), respectively. A total of 54 soil samples were collected and tested for different parameters, including grain size distribution, liquid limit, plastic limit, and plasticity index.

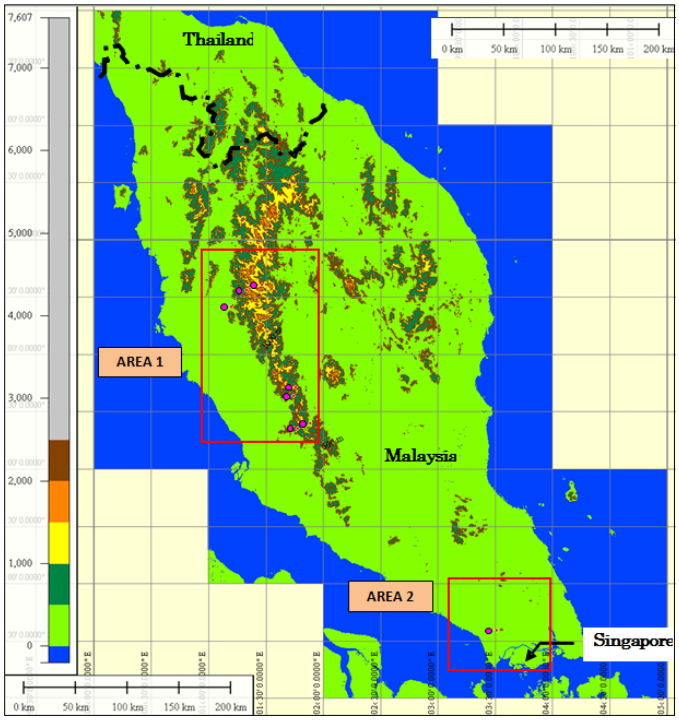


Fig. 1 Locations of grain size distribution samples taken across Peninsular Malaysia. Source: IKRAM [12].

Grain size distribution (i.e., soil fraction) and Atterberg limit values were obtained via laboratory experiments carried out by the Malaysian Institute of Public Works (IKRAM). The ANN and ANFIS models were then examined by utilizing 54 data records collected from these experiments, with the predicted Atterberg limit values compared to the actual data values. ANN and ANFIS models require a set of input and output data for use as a training data set. For the purposes of this study, grain size distributions were employed as input parameters in the development of the ANN and ANFIS models for the prediction of Atterberg limit values.

ISBN: 978-1-61804-224-8

Table 1. Locations of soil samples in Peninsular Malaysia.

No	Area	Location	Total Samples
1	1	Genting Sempah, Pahang	9
2	1	Gua Tempurung, Perak	3
3	1	Lentang, Pahang	4
4	1	Simpang Pulai, Perak	10
5	1	Kuala Kubu Baru, Selangor	7
6	1	Fraser Hill, Pahang	10
7	1	Lojing, Pahang	1
8	2	Gunung Pulai, Johor	10
		Total	54

B. ANN Model

ANN models are generally comprised of three independent layers: input, hidden and output, as shown in Figure 2. Each layer consists of several processing neurons, with each neuron operating in logical similarity. Information is transmitted from one layer to others via serial operations. Whereas the neurons in the input layer include the input values, each neuron in the hidden layer processes these inputs into the neuron outputs. The main function of the hidden layer is to allow the network to detect and capture relevant patterns in the data, and to perform complex non-linear mapping between the input and output variables [13]. A typical ANN structure consists of a number of processing elements (PEs), or nodes, that are usually arranged in the following layers: input, output, and one or more hidden layers (Fig. 2).

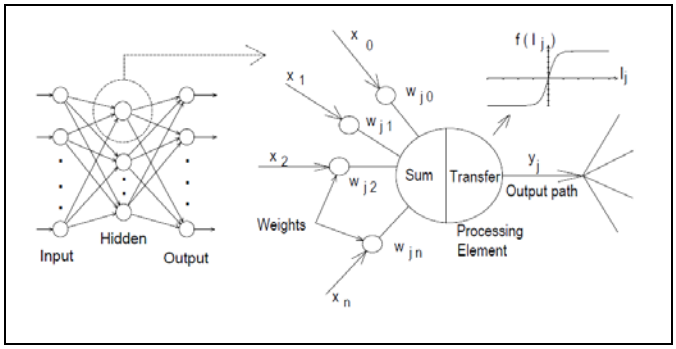


Fig.2 Structure of a typical ANN. Source: Shahin et al. [1].

The input from each PE in the previous layer (x_i) is multiplied by an adjustable connection weight (w_{ji}). At each PE, the weighted input signals are summed and a threshold value (θ_j) is added. This combined input (I_j) is then passed through a non-linear transfer function ($f(I_j)$) to produce the output of the PE (y_j). The output of one PE provides the input to the PEs in the next layer [1]. This process is summarized in Equations 1 and 2 below:

$$I_j = \sum w_{ji} + \theta_j \quad (1)$$

$$y_j = f(I_j) \quad (2)$$

Network weights are adjusted on the presentation of a set of training data, with learning methods employed to find a set of weights that will produce the input / output mapping with the smallest error. This process is known as "learning" or "training". Weight values can be negative depending on the weight and the calculation of different neurons. By adjusting the weight of the artificial neurons, the output for a particular input can be determined [14].

Figure 3 represents a layer of neurons in an ANN network, where R is the number of elements in the input vector and S is the number of neurons in the layer. Each element of the input vector p is connected to each neuron input through the weight matrix W. The i^{th} neuron has a summer that gathers its weighted inputs and bias to form its own scalar output *n(i)*. The various *n(i)* values taken together form an S-element net input vector n. Finally, the neuron layer outputs form a column vector *a*. The expression for *a* is shown at the bottom of the figure. A layer is not constrained in having the number of its inputs equal to the number of its neurons [14].

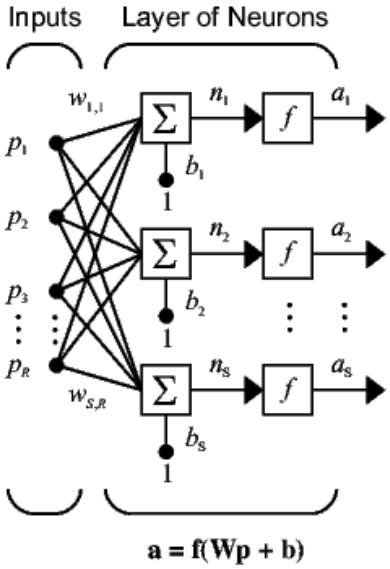


Fig. 3 A one-layer network comprising R input elements and S neurons. Source: Matlab [14].

C. ANFIS Model

An ANFIS has the ability to learn from data, such as that possessed by an artificial neural network. ANFIS models can also rapidly achieve optimal results even if the target is not given. In addition, there is no ambiguity in an ANFIS, unlike in a neural network. Since an ANFIS combines both neural networks and fuzzy logic, it can handle complex and non-linear problems. ANFIS architecture consists of five layers, with the number of neurons in each layer corresponding to the number of rules. For simplicity, we can assume a fuzzy inference system with two inputs x and y, and one output. For a first-order Sugeno fuzzy model, a common rule set with two

ISBN: 978-1-61804-224-8

fuzzy if–then rules is defined as follows:

Rule 1: If x is A_1 and y is B_1, then $f_1 = p_1x + q_1y + r_1$ (3)

Rule 2: If x is A_2 and y is B_2, then $f_2 = p_2x + q_2y + r_2$ (4)

where $\{p_i, q_i, r_i\}$ is the parameter set of this node.

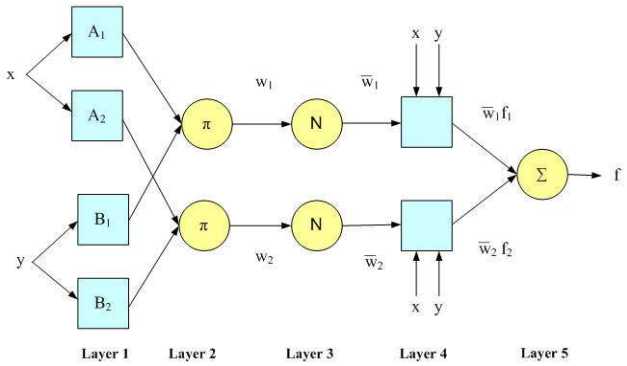


Fig. 4 A typical ANFIS structure. Source: Areerachakul [8]

Figure 4 presents a typical example of ANFIS architecture. Every node in layer 1 is an adaptive node, with a node function that may be a Gaussian membership function or any membership function. Every node in layer 2 is a fixed node labeled π, representing the firing strength of each rule. Every node in layer 3 is a fixed node labeled N, representing the normalized firing strength of each rule. Every node in layer 4 is an adaptive node with a node function. The single node in layer 5 is a fixed node labeled Σ, indicating the overall output (Z) as the summation of all incoming signals [8]. In this study, the Gaussian membership function is used for the input variable, with the hybrid learning algorithm typically employed to determine the parameters of Sugeno-type fuzzy inference systems. For a given training dataset, a combination of the least-squares method and the back-propagation gradient descent method is utilized to update FIS membership function parameters.

D. Modeling Scenario

One of the most important tasks in developing a satisfactory forecasting model is the selection of the input variables, which determines the eventual architecture of the model. For the purposes of the present modeling, the grain size distribution fraction, i.e., the percentage of sand, clay and silt, will be used as an input, and the predicted Atterberg limit values as an output. The ANN and ANFIS models were analyzed by being subjected to specific modifications aimed at investigating their respective responses. For ANN model analysis, two types of modification were applied, namely, the number of inputs used and the percentage of training data set input. As shown in Table 2, the ANFIS model was modified only in terms of the number of inputs.

The MATLAB Neural Network Toolbox was employed for the implementation of ANN analysis, as it is considered to provide the most suitable method with which to train a neural network to fit a function. In contrast, the MATLAB ANFIS Editor GUI toolbox was utilized in order to apply a fuzzy system into the ANFIS forecasting model. As the form of the membership function in the ANFIS system is dependent on the parameters used, varying the latter also changes the former. The ANFIS Editor GUI applications enable the parameters of the membership functions to be used automatically.

Table 2 ANN and ANFIS modeling scenarios

Scenario	Model	Number of Inputs	Performance		
			% Training	% Testing	% Validation
1	ANN	3 = (% sand, % clay & % silt)	70	15	15
2	ANN	3 = (% sand, % clay & % silt)	80	10	10
3	ANN	3 = (% sand, % clay & % silt)	90	5	5
4	ANFIS	3 = (% sand, % clay & % silt)	-	-	-

E. Performance Evaluation

Two statistical methods were selected to analyze the performance and efficiency of the two models: root mean square error (RMSE) and correlation coefficient (R). Both the ANFIS and the ANN model were assessed by evaluating the differences between the observed and predicted values in each analysis. Root Mean Square Error (RMSE) represents the residual value between actual and forecasted Atterberg limits, with the effect on the coefficient more obvious for large errors in forecast values than for smaller errors. An RMSE value of 0 therefore indicates the highest level of model efficiency. RMSE values can be calculated using Eq. 5 as follows:

$$RMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(Y_{i\,observed} - Y_{i\,predicted})^2} \quad (5)$$

The Correlation Coefficient (R) is the square root of the ratio between the explained variation, and ranges from 0 to 1. R values represent the strength and direction of the linear relationship between observed and forecast Atterberg limit values. The formula for R is given by Eq. 6. In the present study, the R^2 value was used to obtain the most accurate evaluation of model performance, with a value of 1 indicating the highest level of model efficiency.

$$R^2 = 1 - \frac{\sum_{j=1}^{N}\left[(Y)_{observed,j} - (Y)_{predicted,j}\right]^2}{\sum_{j=1}^{N}\left[(Y)_{observed,j} - (Y)_{mean\ \ observed}\right]^2} \quad (6)$$

III. Results and Discussion

A. ANN and ANFIS model simulations using 3 sets of input data

The percentage of data used in training the ANN model was 90%, as described in Table 2. Figures 5, 6 and 7 display the predicted values of the ANN and ANFIS models for plastic limit, liquid limit and plasticity index based on 3 input data sets. The 3-input ANFIS model exhibited a strong performance in plasticity index analysis (Fig. 7), with predicted values close to actual values for most samples. However, for liquid limit analysis (Fig. 5) the ANN model produced a huge error in its predicted value of sample 38 when compared to that predicted by the ANFIS model. Both the ANN and ANFIS model produced an error when predicting the plastic limit values of samples 27 and 35.

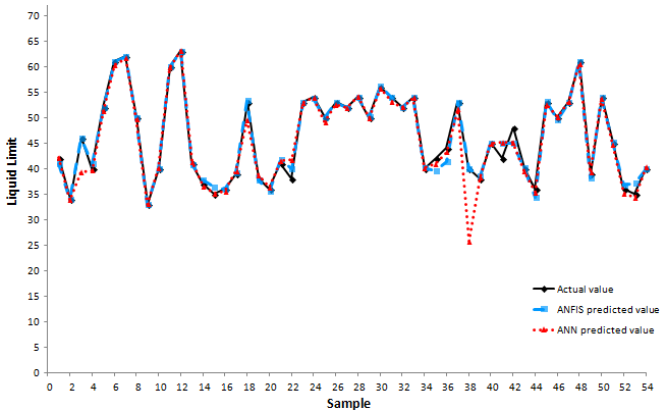


Fig. 5 Predicted and actual liquid limit values using ANN and ANFIS models with 3 inputs

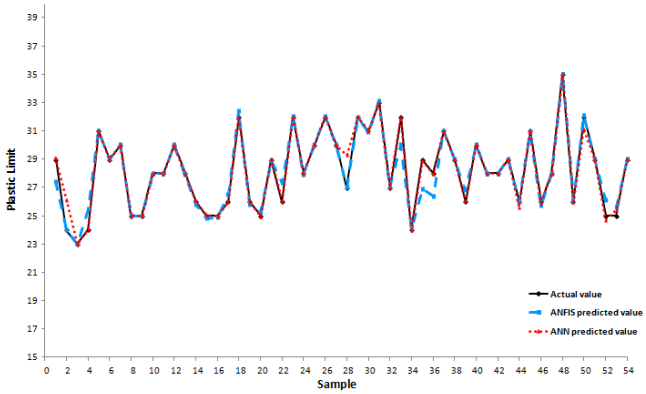


Fig. 6 Predicted and actual plastic limit values using ANN and ANFIS models with 3 inputs

Modification of the ANN model involved varying its performance in terms of training, verification and testing sets. In this study the training data set was tested at three different input percentages of 70%, 80%, and 90%. The remaining percentage of data was divided equally between the validation and test sets, as shown briefly in Table 2. The results are summarized in Table 3. The R^2 values for all three Atterberg limit predictions show that the accuracy of ANN model output increased as the percentage of training performance increased.

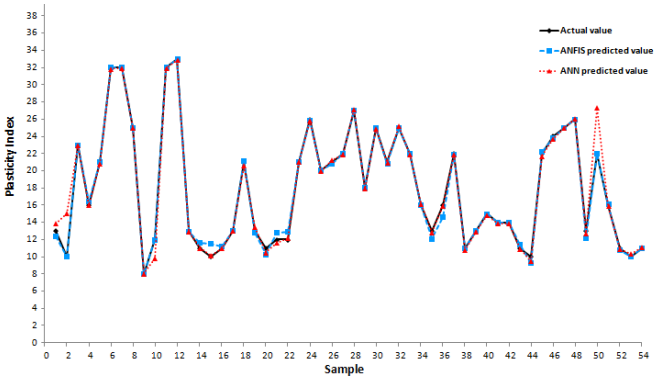


Fig. 5 Predicted and actual plasticity index values using ANN and ANFIS models with 3 inputs

Table 3 Comparison of R^2 values for ANN model training performance

No	Atterberg limit	Performance *(Training)*		
		70%	80%	90%
1	Liquid limit	0.727	0.909	0.928
2	Plastic limit	0.679	0.774	0.974
3	Plasticity Index	0.876	0.891	0.976

B. Determination of Best Model

A comparison of the relative performances of the ANN and ANFIS models with variation in input number can also be observed in the R^2 and RMSE values shown in Table 4. However, ANFIS model is associated with higher R^2 values for predicted liquid limit and plasticity index data. ANFIS model generally performed better than the ANN model in the analysis. The ANFIS model exhibited improved R^2 values when the number of inputs was increased. Overall, increasing the number of input variables had a more positive effect on the operation of the ANFIS model than the ANN model.

The predictive abilities of the ANN and ANFIS models were compared by using 3-input model data, with the distribution of predicted values for the two models plotted in Figs. 5, 6 and 7. It can be observed from these figures that the ANFIS model produced a better result than the ANN model in terms of liquid limit and plasticity index prediction. However, regarding plastic limit analysis, the predicted values produced by the ANN model appear closer to the actual values than those derived from the ANFIS model. Nevertheless, in terms of overall RMSE values, the results demonstrate that the 3-input ANFIS model performed better than the ANN model as all three values are below 1.

ISBN: 978-1-61804-224-8

Table 4 Comparison of R^2 and RMSE values for the ANN and ANFIS models

No	Atterberg limit	R^2		RMSE	
		ANN	ANFIS	ANN	ANFIS
3 Inputs = (% sand, % clay & % silt)					
1	Liquid limit	0.928	0.987	2.374	0.957
2	Plastic limit	0.974	0.949	0.448	0.615
3	Plasticity Index	0.976	0.996	1.061	0.421

Based on the obtained results, the present study has clearly shown that the ANFIS model performed better than the ANN model in predicting Atterberg limit values. The results of this study are in agreement with previous research comparing ANN and ANFIS models carried out by Tiwari et al. [15]. In the latter study the output stability of the ANFIS model was considered adequate, with the model thus selected as the optimum for waste generation forecasting in Durg-Bhilai Twin City, India. The ANN model presented weaker results than the ANFIS model with respect to selected statistical criteria.

IV. Conclusions

This study was conducted with the aim of predicting Atterberg limit values such as liquid limit, plastic limit and plasticity index via the use of ANN and ANFIS models. The efficiency and performance of the two models was then compared and analyzed. From the results obtained, it can be concluded that the ANFIS method was able to produce more accurate predictions than the ANN method in terms of liquid limit (R^2 = 0.987) and plastic index values (R^2 = 0.996), but not plastic limit values (R^2 = 0.949). R^2 and RMSE values obtained for the two methods also indicate that the ANFIS model performed better in predicting Atterberg limit data as a whole.

References

[1] M.A. Shahin, B. Mark, M.B. Jaksa and H.R. Maier, "Artificial neural network applications in geotechnical engineering". Australian Geomechanics. Department of Civil and Environmental Engineering, Adelaide University. 2001.

[2] M. Fukuda, S. Suwa, T. UnoSung, Z. Park and G.H. Hwan Jeong, "Dependence of liquid limit on grain size distribution," Proceedings of the Eleventh International Offshore and Polar Engineering Conference Stavanger, Norway, June 17-22, 2001.

[3] R. Rasmin, "Comparison between sieve analysis & hydrometer with laser particle analyzer to determine particle size distribution," Masters Thesis, Universiti Malaysia Pahang, 2011.

[4] F.J. Chang and Y.T. Chang, "Adaptive neuro-fuzzy inference system for prediction of water level in reservoir," Advances in Water Resources, vol. 29, pp. 1–10, 2006.

[5] A. Hipni, A. El-shafie, A. Najah, O.A. Karim, A. Hussain and M., Mukhlisin, "Daily forecasting of dam water levels: Comparing a support vector machine (SVM) model with adaptive Neuro Fuzzy Inference System (ANFIS)," Water Resources Management, vol. 27, pp. 3803–3823, 2013.

[6] E.K. Lafdani, A.M. Nia, A. Pahlavanravi, A. Ahmadi and M. Jajarmizadeh, "Daily rainfall-runoff prediction and simulation using ANN, ANFIS and conceptual hydrological MIKE11/NAM Models," International Journal of Engineering & Technology Sciences (IJETS), vol. 1, no. 1, pp. 32-50, 2013.

[7] A.T.C. Goh, "Seismic liquefaction potential assessed by neural network," Journal of Geotechnical and Geoenvironmental Engineering ASCE, vil. 120, no. 9, pp. 1467-1480, 1994.

[8] S. Areerachakul, "Comparison of ANFIS and ANN for estimation of biochemical oxygen demand parameter in surface water," International Journal of Chemical and Biological Engineering, vol. 6, pp. 286-290, 2012.

[9] T. Mohamed, A. Kasa and M.R. Taha, "Fuzzy Logic System for Slope Stability Prediction," Advanced Science Engineering Information Technology, vol. 2, pp. 1-2, 2012.

[10] M. Budhu, "Soil Mechanics and Foundations," University of Arizona. John Wiley & Sons, Inc. 2007.

[11] S. Berbenni, V. Favier and M. Berveiller, "Impact of the grain size distribution on the yield stress of heterogeneous materials," International Journal of Plasticity, vol. 23, pp. 114–142, 2007.

[12] IKRAM, "Report of Study on Debris Flow Controlling Factors and Triggering System in Peninsular Malaysia," Malaysian Institute of Public Work, Malaysia, 2011.

[13] M. Mukhlisin, A. El-Shafie and M.R. Taha, "Regularized versus non-regularized neural network model for prediction of saturated soil-water content on weathered granite soil formation," Neural Computing and Applications, vol. 21, pp. 543–553, 2012.

[14] MATLAB, "Version 7.6 (R2008a)," The MathWorks Inc. 2008.

[15] M.K. Tiwari, S. Bajpai and U.K. Dewangan, "Prediction of industrial solid waste with ANFIS model and its comparison with ANN model- A case study of Durg-Bhilai twin city India," International Journal of Engineering and Innovative Technology (IJEIT), vol. 6, no. 2, pp. 192-201, 2012.

Using Updated DurovPwin Program for Hydro-Chemical Data Processing: Case study of Al-Ula area, Saudi Arabia

Abdelaziz M. Al-Bassam, Ahmad R. Khalil, and Osama M. Kassem

***Abstract*—**Understanding the evolution of natural groundwater chemistry requires graphical representation of major dissolved constituents. Expanded Durov diagram was used since 1958. DurovPlot program was widely used, since 1997, to calculate and plot the expanded Durov diagram, but it was running under DOS, which is now obsolete. Therefore, the DurovPwin program was first introduced in 2012, to calculate the Durov coordinates and plot it. It also plots the TDS (Total Dissolved Solids) and the measure of the activity of hydrogen ion (pH) of the given samples. However, it still needs some additional features to be more users friendly specially to handle old data stored on Excel sheets.

Many features have been added to improve the DurovPwin program facilities. One of the added features is the interface between the DurovPwin program and Microsoft office package so that users can read data from Excel, which in turn can read ASCII files; also the program automatically writes interpretation report in Microsoft Word format. Another added feature is modifying the X-Y plot to group up to three anions versus up to 3 cations to help data interpretations. The user can also select the electric balance (10% is default). The facility to group wells according the water content is given to help user to plot these group of wells on a map to identify water types in specified area. Another feature is calculating the sodium adsorption ratio (SAR) which is important for irrigation purposes. All results and interpretations are written automatically in the output Microsoft Office Word file. The last feature added is including the Schoeller diagram where actual sample concentrations (meq/l) are displayed and compared.

A case study data from Al-Ula area, Saudi Arabia is used to confirm the correctness of results and to show the great features added. A set of 22 groundwater samples were collected from Al-Ula area and data were saved in excel. Using DurovPwin, automatic scaling of pH shows the wells with minimum and maximum pH values. Automatic analysis report shows the interpretations of the wells located in expanded Durov fields 5, 6, 7, 8 and 9. The X-Y scatter diagrams show relations between many hydro-chemical elements. Finally, Schoeller Diagram is created.

***Keywords*—**DurovPlot program, DurovPwin program, Ground water, Hydro-Chemical analysis, Schoeller Diagram.

I. Introduction

GRAPHICALrepresentations of hydro-chemical data pose considerable problems. Hydro-chemical diagrams need to be comprehensive and should facilitate interpretation of evolutionary trends and hydro-chemical processes. Few diagrams rarely really posses these features. Tri linear diagram is used to represent groundwater chemistry; it was first attempted by Hill (1940) and refined by Piper [8]. An alternative diagram was introduced by Durov in 1948 where the major ions are plotted on the bases of 100 per cent in appropriate triangle and projected into 9 main squares fields. Burdon &Mazloum [2] and Lloyd [3] developed the expanded version of the Durov diagram, where the cation and anion triangles are recognized and separated along the 25 percent axes so that the main field is conveniently divided.

Original Durov diagram consists of 2 triangles where hydro-chemical data is plotted (the major anions on the left triangle and the major cations on the upper triangle). The two points on the triangles are projected on the rectangle. The Expanded Durov Diagram subdivided the rectangle into 9 equal fields. Each of the two triangles on the original Durov Diagram (the cation and anion triangles) are recognized and separated along the 25 per cent axes so that the main field is conveniently divided (Fig. 1). TDS and pH are plotted on the other two sides of the rectangle. In the DurovPwin program the TDS and pH are plotted on right side of the rectangle (Fig. 2).

Durov diagram needs a lot of calculations and is considered tedious and time consuming process therefore, computer programs are a must. Some programs were written to use the computer power to overcome the amount of work and to shorten the time [4]. Some commercial programs are used to plot the Durov diagram such as AquaChem and AqQA from

This work was supported in part by the Deanship of Scientific Research at King Saud University and for its funding of this research through the Research Group project no RGP-VPP-230.

A. M. Al-Bassam, Saudi Geological Survey Research Chair, Dept. of Geology and Geophysics, College of Science, King Saud University, Saudi Arabia.

A. R. Khalil was with Saudi Geological Survey Research Chair for Natural Hazards, KSU, Saudi Arabia. He is now with College of Computing and Information Technology, Shaqra University, Saudi Arabia. (corresponding author: Mobile: +966557177115, Email: arkhalil44@gmail.com)

O. M. Kassem, was with Department of Geology, National Research Center, Al-Behoos str., 12622 Dokki, Cairo, Egypt and now he is with Saudi Geological Survey Research Chair, Dept. of Geology and Geophysics, College of Science, King Saud University, Saudi Arabia.

RockWare, Inc. programs and similar ones, but none of it is specialized in expanded Durov diagram and none is goes deep in its features to help in analysis and fast automatic interpretation of water constituents. The nine subfields of the expanded Durov diagram allow initial possible insights into hydro-chemical differences, relationships and origins, while providing a convenient means of illustrating these factors.

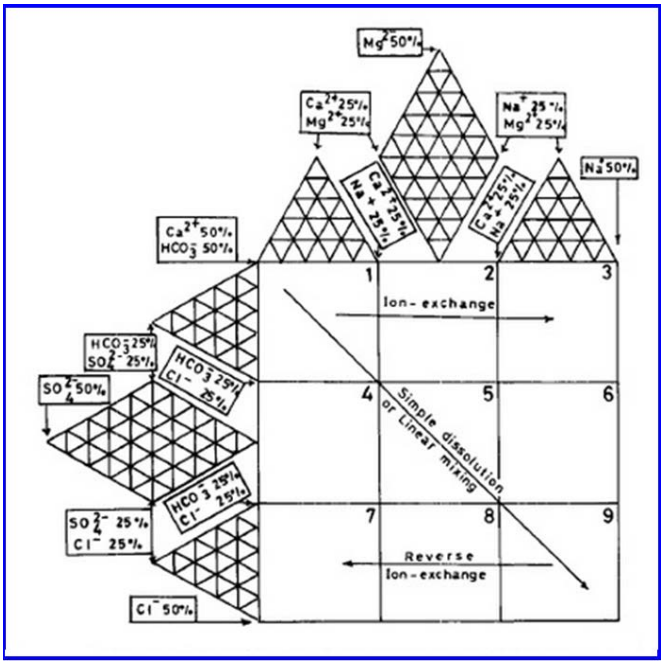


Fig. 1 Expanded Durov diagram with subdivision and processes demonstrated [9].

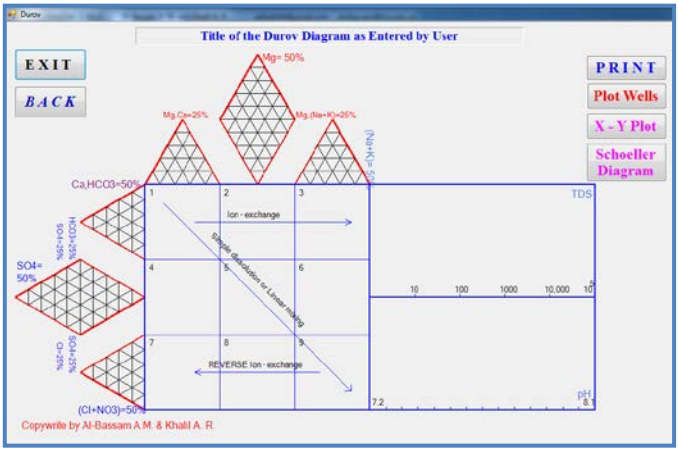


Fig. 2 The expanded Durov diagram as presented in DurovPwin program

"DurovPlot" program was designed and written using ''Basic'' computer language which runs in the Disk Operating System (DOS) environment [4]. Since Dos now is obsolete, therefore a new program is designed and written using visual studio 2010. The DurovPwin program was first announced by Al-Bassam and Khalil [1], where ***"DurovPwin"*** (stands for ***DurovPlot*** under ***Win***dows). The integration of the DurovPwin program with other hydro-chemical data analysis and manipulation packages like RockWorks and AqQA from RockWare, Inc., is possible and considered as additional feature in addition to the ability to link to the popular geochemical modeling program PHREEQC for calculating equilibrium concentrations. Ion-exchange process, Simple dissolution or mixing processes and reverse ion-exchange processes are displayed in the 9 sub-fields and compared with the TDS data plotted in the same diagram.

II. New Feature and Updated Improvements of DurovPwin Program

In this study, the updated version of DurovPwin program was used and tested on the sample data from Al-Ula area to check results correctness and to show the new features of the program. Five important features are added to the DurovPwin program to improve its user friendly feature and to add more facilities to analyze hydro-chemical data. The interface with the widely used Microsoft office package (Excel and Word) is the first feature added to improve the flexibility of different data input format. The hydro-chemical data samples can be stored in an ASCII format or in a report table of word format, and then it can be read into Microsoft Excel and read by DurovPwin. Also, the final results of all calculations of meq/l and the Durov coordinates (percent meq/l) are listed in an automatic report of Microsoft Word format. The first part of the automatic word report contains of three tables. These tables are the input raw data in a table of the major cations and anionselements concentrations in mg/L followed by a calculated milli-equivalent per liter table which also include cation/anion balance column and the third table is Durov coordinates (meq/l percentage).Cation/Anion (Charge) balance is calculated as follows:

(Charge) Balance = (Σcations–Σanions) / (Σcations+Σanions)

The second feature added is calculating the sodium adsorption ratio (SAR) in a new column of the third table of the output report (Major Ion Concentrations Percentage (Durov Diagram Coordinates). Interpretation of water quality according to expanded Durov diagram depends on projection of sampled data on the nine fields [9]. In case of arid areas, as in Saudi Arabia, hydro-chemical data of water quality assessment is important for irrigation purposes [5]. One of irrigation techniques is the United States Department of Agriculture (USDA) [10] which is mainly based on water electric conductivity (EC_w), representing the total concentration of soluble salts in irrigation waters, usually expressed in µS/cm and its sodium adsorption ratio (SAR). Excessive SAR value is an indicator of Sodium hazard (alkali hazard) [5]. The sodium adsorption ratio (SAR) is calculated using the following equation:

$$SAR = Na^{+} / [(Ca^{2+} + Mg^{2+})/ 2]^{1/2}$$

Where, Na^{+} is the concentration of sodium ions (meq/l), Ca^{2+} the concentration of calcium ions (meq/l), and Mg^{2+} is the concentration of magnesium ions (meq/l).

ISBN: 978-1-61804-224-8

The third new added feature is the Shoeller diagram which is another multiple parameter plots like Piper, Ternary and Durov. Each of these plots provides a unique interpretation of the many complex interactions between the groundwater and aquifer materials, and identifies important data trends and groupings. Schoeller diagrams show concentration ranges in the vertical direction and constituents of interest along the horizontal axis. A line connects the constituents concentration for each sample represented. These semi-logarithmic diagrams were developed to represent major ion analyses in meq/l and to demonstrate different hydro-chemical water types on the same diagram. This type of graphical representation has the advantage that unlike the trilinear diagrams, actual sample concentrations are displayed and compared. The Schoeller diagram in DurovPwin program can be used to plot all samples or selected sample groups only (http://www.ground-water-models.com/products/aquachem details/aquachem_details.html

The last two features are improvements to the last version of DurovPwin program version 1 [1].The X-Y scatter plots are the simplest initial approach to the interpretation of geochemical data. Single plots of ion relationship and parameters that show significant data can be easily created and patterns are quickly identified and easily understood. The modification is the ability to plot combined cations versus combined anions. This version is giving the choice of combining up to three anions versus up to three anions and the scattered X-Y plot. This gives a better facility for faster and easier interpretation of the constituent's relationships. The last feature improvement is the automatic scaling of pH, since in many cases, during analysis and data processing of groups or subgroups of sampled data of an aquifer, the pH values lies in small range rather than from 1 to 15 therefore the automatic scaling spread the different samples between its maximum and minimum. The experience during data analysis shows that plotting the pH values which is the measure of activity of hydrogen ions on a linear plot of a range from 1 to 15 results on plotting the wells very near to each other or even overlapped. Therefore, to make easier interpretation or selecting groups of samples, the plot should be spread over its range of values.

III. Process Flowchart

Process flowcharts are used primarily in process engineering and chemical industry where there is a requirement of depicting the relationship between major components only. The main reason of using process flowchart is to show the relation between major parts of the program. The flowchart of DurovPwin program has been changed to meet all the above developments. Figure 3 shows a process flow chart to represent the main procedure steps. The process starts by creating the Microsoft Excel interface and read Hydro-chemical Excel file, all other input data format like CSV files and ASCII files are read first by Excel. Next step is calculating meq, percent meq (Durov coordinates) and sodium adsorption ratio (SAR) for each sample. Then another interface to Microsoft Word is created and user can choose where to create the output report which contains three tables. First table contains raw data which is the major ions concentration in mg/L, pH and TDS. The second and third tables are milli-equivalent/liter values (meq/l) and percent meq/l which is Durov coordinates). The user is still on the main screen, which contains four buttons (Read Water Chemical Data, Expanded Durov Diagram, X-Y Plotting and Exit button) and a welcome banner (Fig. 4). All the above steps are done by pressing the first button. The second screen is the expanded Durov diagram, where user has a lot of options. One of these options is to plot all the wells at once and enter the title of the diagram. Another option is to plot each well at a time and decide even to cancel it (if it express an odd water characteristics) or to save in a group. The program can have up to four groups according to its location on the Durov nine fields. Grouping gave the user the ability to study the detailed characteristics of the group water quality. From the flowchart (Fig. 3), it is clear that an automatic analysis report is created by the end of each run which is one of the major improvements of the program.The program was tested on the Al Ula data and the output file is found greatly improved with no computational errors. The new added feature is the Schoeller diagram button. Schoeller diagram is one of the commonly used diagrams for showing water quality, the semilog milli-equivalent diagram introduced by Schoeller [11] which allows quantitative as well as comparative perspectives.The horizontal axis contains the major ions (K, Mg, Ca, Na, Cl, So_4, HCO_3, and NO3) and the vertical semi-Log axis ranges from 0.01 to 1000 which represent the meq values and not the percent values.

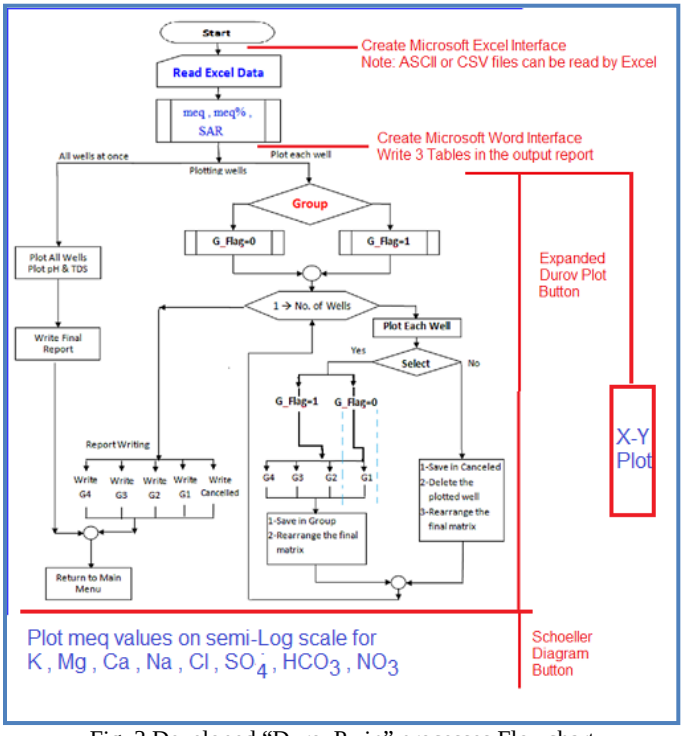


Fig. 3 Developed "DurovPwin" processes Flowchart

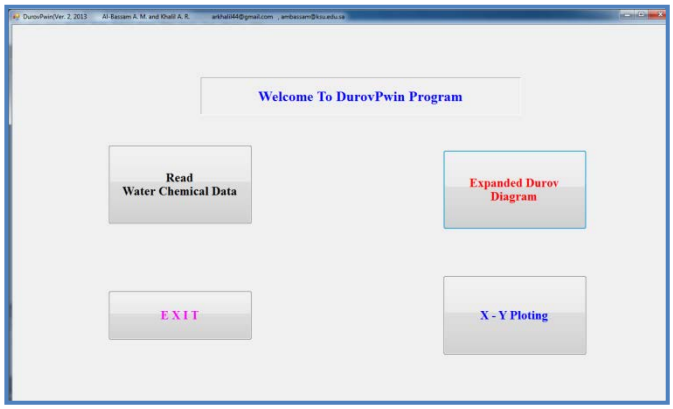


Fig 4 The opening screen of the DurovPwin program

IV. Case Study (Analyses of Water Samples from Al-Ula Area, Saudi Arabia)

A. Geological Setting:

The Al Ula area is located 380 km northeast of Madinah (26° 40' 30" N, 37° 55' 30" E) in the west-central part of the late Proterozoic Arabian shield (Figure 5). Many authors studied the geology and mineralization of the Al Ula area [6, 7]. Al Ula area consists of different type of rocks such as Jizl formation, Jibalah group (basement rocks), Harrat al Uwayrid (Tertiary basalt) and Siq sandstone, Quweira sandstone and wadi alluvium (sedimentaryrocks).

Jizl formation contents of felsic follows and pyroclastic rocks along the southern boundary of Harrat al Uwayrid in theAl Ula area [7]. Jibalah group is the youngest layered sequence of the Arabian shield [6]. It includes boulder conglomerate of both polymictic and volcanic conglomerate (Fig. 5).

Harrat al Uwayrid basalt field is the southeastern extension of a large plateau basalt field that extends northwesterly near Al Ula area. The basalt is flat and unconformably overlies the Siq Sandstone along the harrat. Basal flow of Harrat al Uwayrid locally overlies lag deposits of silicified marine fossils. Lavas of Harrat al Uwayrid are bimodal and consist of basal flow of macrocrystalline picrite ankaramite, middle flows that are silicic in some position and upper flows of diktytaxitic alkali- olivine basalt (Fig. 5).

Saq sandstone is one of four sandstones making up the Saq Sandstone [11] which is shown as Saq Sandstone in the structural sketch map. The Siq sandstone consists of dark-red to reddish brown sandstone and pebble conglomerate. It is generally very friable, medium to coarse grained and composed of strongly cross-bedded layers. TheSaq sandstone is arkosic, monocrystalline and polycrystalline quartz. The original cement was calcite, but that was later replaced by microcrystalline quartz. Furthermore, Quweira sandstone is equivalent to the upper part of the Saq Sandstone of Powers et al., 1966. It was described by many authors such as (Bramkamp and Brown [14, 15]. Quweira sandstone is reddish brown medium grained and uniformly bedded. It shows excellent graded bedding and commonly have ripple marked surfaces (Fig. 5). The Quaternary consists of many type alluviums such as pediment Alluvium, Wadi Alluvium and Eolian sand. The pediment Alluvium is medium to coarse grained surrounds bedrock outcrops fills wadi systems. In addition, Wadi Alluvium is unconsolidated; fine to conglomeratic, commonly well stated material occupies wadi channels. The larger wadies generally have modern channels flanked by well stratified agricultural purposes where subsurface water is available locally. Eolian sand covers jabals and is mixed with unconsolidated Quarternary deposits. The sand is very fine and reddish brown to reddish orange (Fig. 5).

B. Geological Setting:

The Al Ula area is located 380 km northeast of Madinah (26° 40' 30" N, 37° 55' 30" E) in the west-central part of the late Proterozoic Arabian shield (Figure 5). Many authors studied the geology and mineralization of the Al Ula area [6, 7]. Al Ula area consists of different type of rocks such as Jizl formation, Jibalah group (basement rocks), Harrat al Uwayrid (Tertiary basalt) and Saq sandstone, Quweira sandstone and wadi alluvium (sedimentaryrocks).

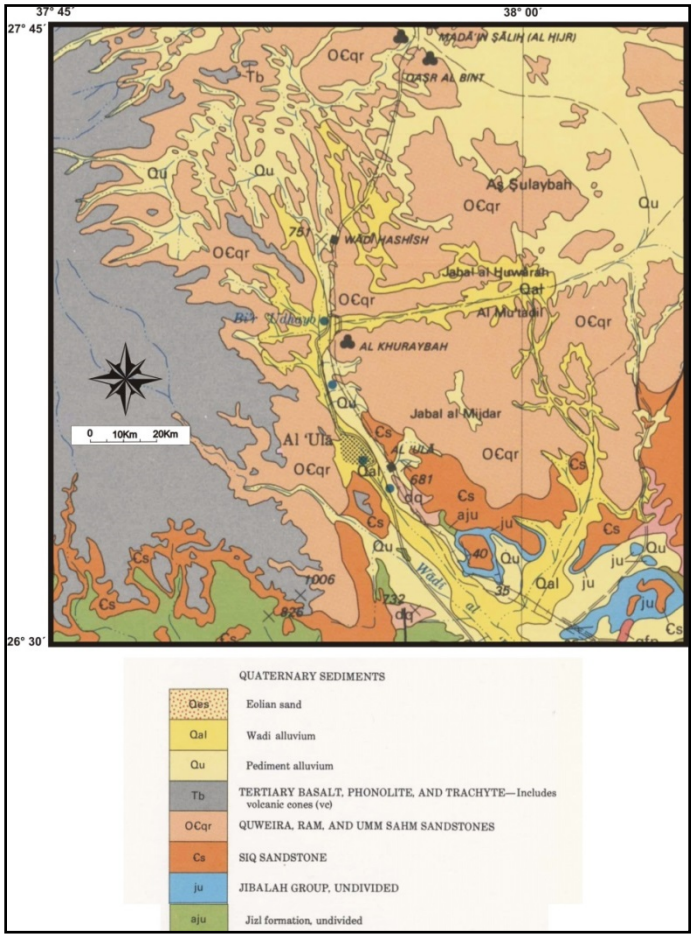


Fig. 5 Geological map for Al Ula area (Modified after Donald and Hadly, 1987) [7].

Jizl formation contents of felsic follows and pyroclastic rocks along the southern boundary of Harrat al Uwayrid in

theAl Ula area [7]. Jibalah group is the youngest layered sequence of the Arabian shield [6]. It includes boulder conglomerate of both polymictic and volcanic conglomerate (Fig. 5).

Harrat al Uwayrid basalt field is the southeastern extension of a large plateau basalt field that extends northwesterly near Al Ula area. The basalt is flat and unconformably overlies the Siq Sandstone along the harrat. Basal flow of Harrat al Uwayrid locally overlies lag deposits of silicified marine fossils. Lavas of Harrat al Uwayrid are bimodal and consist of basal flow of macrocrystalline picrite ankaramite, middle flows that are silicic in some position and upper flows of diktytaxitic alkali- olivine basalt (Fig. 5).

Saq sandstone is one of four sandstones making up the Saq Sandstone [11] which is shown as Saq Sandstone in the structural sketch map. The Siq sandstone consists of dark-red to reddish brown sandstone and pebble conglomerate. It is generally very friable, medium to coarse grained and composed of strongly cross-bedded layers. TheSaq sandstone is arkosic, monocrystalline and polycrystalline quartz. The original cement was calcite, but that was later replaced by microcrystalline quartz. Furthermore, Quweira sandstone is equivalent to the upper part of the Saq Sandstone of Powers et al., 1966. It was described by many authors such as (Bramkamp et al., 1963 and Brown et al., 1963) [14, 15]. Quweira sandstone is reddish brown medium grained and uniformly bedded. It shows excellent graded bedding and commonly have ripple marked surfaces (Fig. 5). The Quaternary consists of many type alluviums such as pediment Alluvium, Wadi Alluvium and Eolian sand. The pediment Alluvium is medium to coarse grained surrounds bedrock outcrops fills wadi systems. In addition, Wadi Alluvium is unconsolidated; fine to conglomeratic, commonly well stated material occupies wadi channels. The larger wadies generally have modern channels flanked by well stratified agricultural purposes where subsurface water is available locally. Eolian sand covers jabals and is mixed with unconsolidated Quarternary deposits. The sand is very fine and reddish brown to reddish orange (Fig. 5).

C. Hydro-Chemical Analysis

Quality of water is determined by its chemistry. The analyzed chemical data from the water samples are used for various purposes, such as classification, analysis, correlation, etc. For these purposes, the data need to be compiled and statistically evaluated. Graphical and numerical interpretation is a basic tool in hydro-chemical studies, which is used for summarizing and presenting water quality data.

The most commonly used diagrams for showing water quality, the semi-log milli-equivalent (not percent) diagram introduced by Schoeller [12] was chosen here for our case study. The DurovPwin program is used to compare with the previous results and to show the new features of the user friendly program to analyze hydro-chemical data and present it in an easy and meaningful way. The program also automatic generates the preliminary report of the data analysis and chemical interpretation data.

The hydrochemistry data obtained from the final BRGM report for the Ministry of Agriculture and Water, Water Resources Development Department, Saudi Arabia [8]. The updated DurovPwin program reads this excel file and confirm the output analysis report word file location. The Durov output diagram for Al-Ula data is shown in fig. 6.

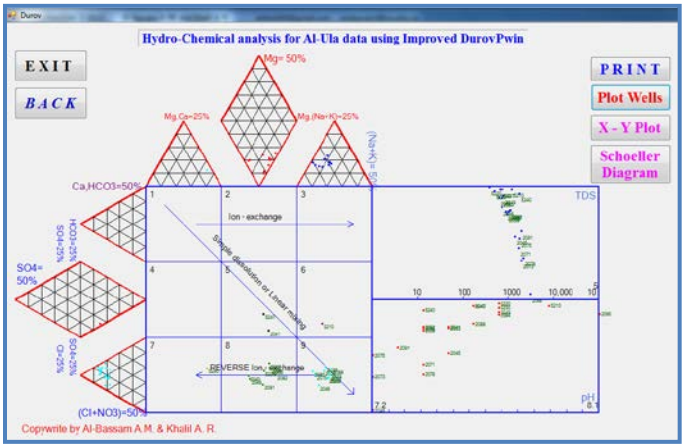
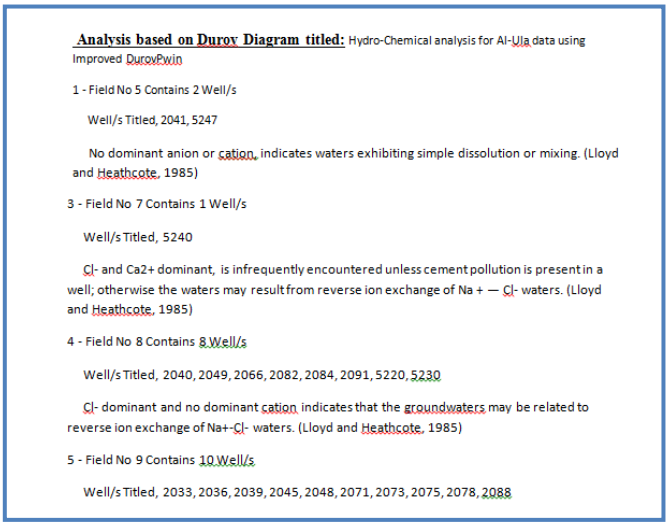


Fig. 6 The Durov diagram for Al-Ula area as given by DurovPwin program.

Figure 6 shows, from just a glance, some important conclusions. First, there is reverse ion exchange which is clear since 19 water samples located in the fields 7, 8 and 9. Samples located in the field 5 (2041, 5274) shows simple dissolution or linear mixing One feature of the DurovPwin program is the automatic analysis interpretation report created in Microsoft Word format as shown in figure **7**. It showsthat sub-field 8 contains wells number 2040, 2049, 2066, 2082, 2084, 2091, 5220, 5230, this indicate that Cl- dominant and no dominant cation shows that the groundwaters may be related to reverse ion exchange of Na+-Cl- waters [9]. The sub-fields 9 of the expanded Durov diagram contains 10 wells. These wells are 2033, 2036, 2039, 2045, 2048, 2071, 2073, 2075, 2078, 2088, which shows that "Cl- and Na+ are dominant and indicate end-point waters. The Durov diagram does not permit much distinction between Na+-Cl- waters [9]. The detailed report is saved where the user likes.

Another feature of the updated DurovPwin program is the automatic scaling of the pH plot. Figure 6 also shows that the pH values varies between 7.2 to 8.1 and the well name 2066 have the maximum pH value (pH = 8.1) and minimum pH value is 7.2 from the water analysis of the well numbers 2075, 2073 and 2048. Since the pH values in the study area varies between 7.2 up to 8.1, plotting it on the full pH value scale (from 1 to 15), the wells will overlap and the conclusion will not be clear. The new feature of the updated version is the automatic scaling of the pH values.

ISBN: 978-1-61804-224-8



Analysis based on Durov Diagram titled: Hydro-Chemical analysis for Al-Ula data using Improved DurovPwin

1 - Field No 5 Contains 2 Well/s

Well/s Titled, 2041, 5247

No dominant anion or cation, indicates waters exhibiting simple dissolution or mixing. (Lloyd and Heathcote, 1985)

3 - Field No 7 Contains 1 Well/s

Well/s Titled, 5240

Cl- and Ca2+ dominant, is infrequently encountered unless cement pollution is present in a well; otherwise the waters may result from reverse ion exchange of Na + — Cl- waters. (Lloyd and Heathcote, 1985)

4 - Field No 8 Contains 8 Well/s

Well/s Titled, 2040, 2049, 2066, 2082, 2084, 2091, 5220, 5230

Cl- dominant and no dominant cation indicates that the groundwaters may be related to reverse ion exchange of Na+-Cl- waters. (Lloyd and Heathcote, 1985)

5 - Field No 9 Contains 10 Well/s

Well/s Titled, 2033, 2036, 2039, 2045, 2048, 2071, 2073, 2075, 2078, 2088

Fig. 7 Part of the Automatic analysis interpretation report for the Expanded Durov sub-fields.

One more feature of the updated DurovPwin program, is plotting the TDS values on log scale on one side of the expanded Durov diagram as shown in figure **6**. This feature and the automatic interpretation report helps to see the range of the Total Dissolved Solids (TDS) values of the samples. In the Al-Ula area, the values range from 366 till 2963mg/l.

Another feature of the updated Durov program is summing up to 3 elements on the x-axis versus up to 3 elements in y-axis in the scattered X-Y plot. For Al-Ula case study, the six X-Y scatter plot relations were required for hydro-chemical analysis report.These relations are Ca^{2+} versus Mg^{2+} , Ca^{2+} versus Na^{+} , Na^{+} versus $(Ca^{2+} + Mg^{2+})$, $HCO3^{-}$ versus Cl^{-} , SO_4^{2} versus Cl^{-} and finally Na^{+} versus Cl^{-}. Figure 8 shows one of these relations which is Na^{+} versus $(Ca^{2+} + Mg^{2+})$ that requires the summation of $(Ca^{2+} + Mg^{2+})$ before plotting which is one advantage of the updated DurovPwin program.

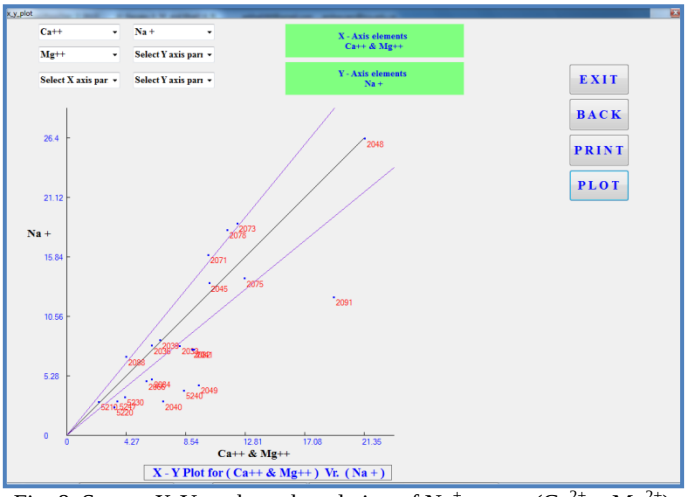


Fig. 8. Scatter X-Y to show the relation of Na^{+} versus $(Ca^{2+} + Mg^{2+})$

From fig. 8, user can easily conclude the water samples which are out of the acceptable balance range considered as ±10% as shown by the two lines from the diagonal line. Some possible reasons for electrical imbalance are the negligence in analyzing a major dissolved species. This may indicate a high concentration of an unusual anion or cation. The second possible reason is laboratory error where some serious systematic error occurred or in certain cases the dissolved species of the element of a compound may not correspond to typical species used in making the ion balance calculation.

Graphical analysis of constituent relationships included using Schoeller semi-logarithmic diagram and different X-Y plots. Schoeller Diagrams facility is a new added feature in the Improved DurovPwin program. These semi-logarithmic diagrams were developed to represent major ion analyses in meq/l and to demonstrate different hydro-chemical water types on the same diagram. This type of graphical representation has the advantage that unlike the tri-linear diagrams, actual sample concentrations are displayed and compared. The Schoeller diagram in DurovPwin program can be used to plot all samples or selected sample groups only. Eight different parameters are included along the x-axis. These elements are K, Mg, Ca, Na, Cl, SO_4, HCO_3 and NO_3. Logarithmic diagrams of major ion analysis in meq/L demonstrate different water types on the same diagram. Figure 9 shows the Schoeller diagram of Al-Ula case study data without any grouping of the samples.

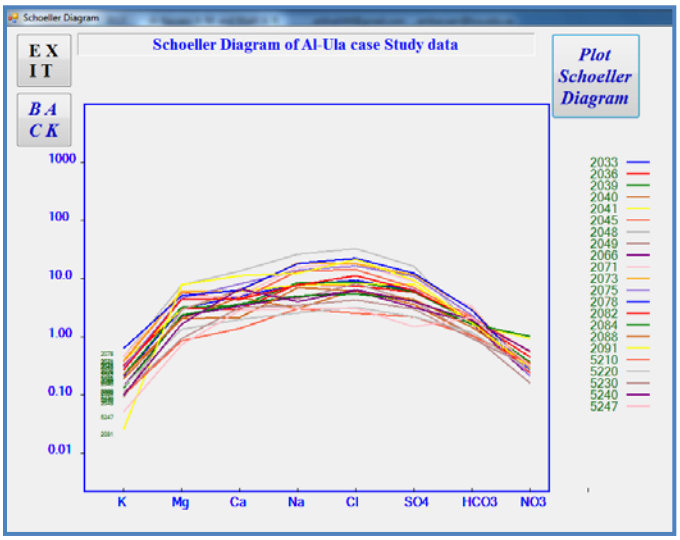


Fig. 9. Al-Ula case study data as represented by Schoeller diagram.

V. Results and Discussion

Sample data collected from 22 wells in the study area (Al-Ula area, Saudi Arabia) and analyzed using the improved DurovPwin program. The results were compared with the previous studies. The updated version proved more user friendly and provides more analysis facilities. The program is users friendly through the interface with Microsoft Word and Excel programs. Different input data files such as plain text ASCII or CSV can be read by Microsoft Excel which is input tool of the program. Used input data and all calculation results are saved in tables in Microsoft Word files which can be

ISBN: 978-1-61804-224-8

copied later to Excel to be updated with new data or regrouped. The output word file also contains some data interpretations such as the content of field number 6 of the Durov diagram contains only one well (well number 5210), and this water sample shows SO_4^{2-} and Na+ dominance. This is a water type not frequently encountered and indicates probable mixing influences [9]. Also, water samples located in fields 7, 8, and 9 which are numbered as 5240, 2040, 2049, 2066, 2082, 2084, 2091, 5220, 5230, 2033, 2036, 2039, 2045, 2048, 2071, 2073, 2075, 2078, and 2088 indicate that there is reverse ion exchange as detailed in automatic word document report.

The pH values in the study area vary between 7.2 up to 8.1 as shown in the full pH-scale of the expanded Durov Diagram and it confirmed the input data table. Also TDS values lies in the range of 366 till 2963 which is shown on a log scale. The Schoeller diagram gives absolute concentration, but the line also gives the ratio between two ions in the same sample. If a line joining two points representing ionic concentrations in a single sample is parallel to another line joining a second set of concentrations from another sample, the ratio of those ions in those samples are equal.

VI. Conclusions

In this study, water samples were collected from 22 wells located in Al-Ula area, Saudi Arabia which is about 380 Km north-east of Al-Madinah (26.675N, 37.925E) in the west central part of the late Proterozoic Arabian shield. From the geology of the study area, we can see that the rock environments affected the water quality.

The developed program of DurovPwin makes significant improvement with added features and more user friendly interface. The automatic output report is in the format of Microsoft word package which is widely used. The program also accepts the input data file in the Microsoft Excel.

All the input and calculated data are correct and the plots are reviewed with either old plots or plots using other programs for the same data. The improvements show a great advantage to clear the ambiguity of plotting the water samples on the pH scale showing its sample number and not overlapping. Having the schoeller diagram is another new addition to improved DurovPwin program and plays an important rule to confirm the hydro-chemical data analysis.

Acknowledgment

The authors would like to extend their sincere appreciation to the Deanship of Scientific Research at King Saud University for its funding of this research through the Research Group project no RGP-VPP-230. We thank journal reviewers for critical and helpful comments and for editorial handling.

References

[1] Al-Bassam A. M., & Khalil, A. R, DurovPwin: A new version to plot the expanded Durov diagram for hydro-chemical data analysis, Computers & Geosciences 21, 2012, pp. 1-6.

[2] Burdon, D. J., and Mazloum, S., Some chemical types of groundwater from Syria. UNESCO Symp., Tehran. UNESCO, Paris, 1958, pp. 73-90.

[3] Lloyd J. W., The hydrochemistry of the aquifers of the North-eastern Jordan.Journal of Hydrology 3, 1965, 319–330.

[4] Al-Bassam, A. M., Awad H. S., &Al-Alawi,J. A.(1997).DurovPwin: DurovPlot: A Computer Program for Processing and Plotting Hydro-chemical Data, Vol. 35, No. 2-GROUND WATER-Computer Notes, pp. 362-367.

[5] Arabia, Journal of African Earth Sciences 36, 345–356.

[6] Binda, P. L., & Ramsay, C. R. (1980). Earliest Phanerozic or latest Proterozic fossils from the Arabian Shield- A discussion; Precambrian Research, v. 13, p. 375-377.

[7] Donald G. &Hadly, G. (1987). Explanatory notes to the Geological map of the Sahl Al Matran Quadrangle, sheet 26 C, Kingdom of Saudi Arabia, pp,1-24.

[8] Piper, A.M., (1944). A graphic procedure in the geochemical interpretation of water analyses. Transactions, American Geophysical Union 25, 914-924.

[9] Lloyd J. W. and Heathcote, J.A. (1985). Natural Inorganic Hydrochemistry in Relation to Groundwater: An Introduction. Clarendon Press, Oxford, pp. 294.

[10] Richards, L.A., (1954). Diagnosis and Improvement of Saline and Alkali Soils. In: agricultural Handbook, vol. 60. US Department of Agriculture, Washington DC, P. 218.

[11] Powers, R. W., Ramirez, L. F., Redmond, C. D., &Elberg, E. L., (1966). Geology of the Arabian Peninsula Sedimentary geology of Saudi Arabia: U. S. Geological Survey Professional paper 560-D, 147p.

[12] Freeze, R. A., and J. A. Cherry, (1979). Groundwater: Englewood Cliffs, New Jersey, Prentice Hall, 604 p.

[13] Ministry of Agriculture and Water, Water Resources Development Department, Saudi Arabia, (1985). Water, Agriculture and Soil Studies of SAQ and Overlying Aquifers (Final Report), Volume 2, Water studies – Appendix 6 – water quality studies, PP. 358.

[14] Bramkamp, R. A., Layne, N. M., Holm, D. A., & Brown, G. F.(1963). Geological map of the Wadi as Sirhan Quadrangle, Kingdom of Saudi Arabia, U. S. Geological Survey Miscellaneous Geologic Investigations Map I-200A, scale 1:500000.

[15] Brown, G. F., Jackson, R. O., Bogue, R. G., &Elberg, E. L.(1963). Geological map of the northwestern Hijaz Quadrangle, Kingdom of Saudi Arabia, U. S. Geological Survey Miscellaneous Geologic Investigations Map I-204A, scale 1:500000.

[16] http://www.ground-water-models.com/products/aquachem_details/aquachem_details.html

The analysis of the possible use of harvested rainwater in real conditions at the university campus of Kosice

Gabriel Markovič, Daniela Kaposztásová, Zuzana Vranayová

***Abstract*—**One of the biggest problems of new millennium is water resources management. Submitted article reflects a need for more effective handling with rainwater and storm water in urban areas. Continuous growth of population and consequent growing need for drinking water is a global problem which leads to a search for new ways of effective use of water resources not only of drinking water but also of service water and rainwater. Any kind of enhancing of drinking water effective use for human needs only and minimizing of drinking water use for any other purpose has an important meaning toward our future. One of the reasons is the fact that drinking water resources will be disappearing and the need for drinking water will be growing with growing population. Effective use of rainwater from infiltration systems and capturing rainwater for further reuse represents one of alternatives of saving so precious drinking water.

***Keywords*—**rainwater, rainwater harvesting, water demand

I. Introduction

THE use of rainwater is an alternative method of water supply compared to the traditional way through the public water supply.

Every building has potential to be used for capturing rainwater. Rainwater can be used for various activities in the buildings:

- flushing the toilet
- irrigation
- washing
- laundry
- use of rainwater for heating system
- rainwater is used also as drinking water after necessary treatment in some countries

Figure 1 shows the average daily consumption of water of a household - 150 l/person per day. It shows that about 60% of drinking water may be replaced by rainwater. This fact gives credit to reuse of rainwater mostly from the environmental point of view. Among other, reuse of rainwater minimizes the flow of rainwater to waste-water disposal system. Even though rooftop surface represents only a fragment of all urban surface area, drainage of rainwater from rooftops into storage reservoirs minimizes the flow of rainwater to waste-water disposal system and has positive impact on sewerage system.[1], [2].

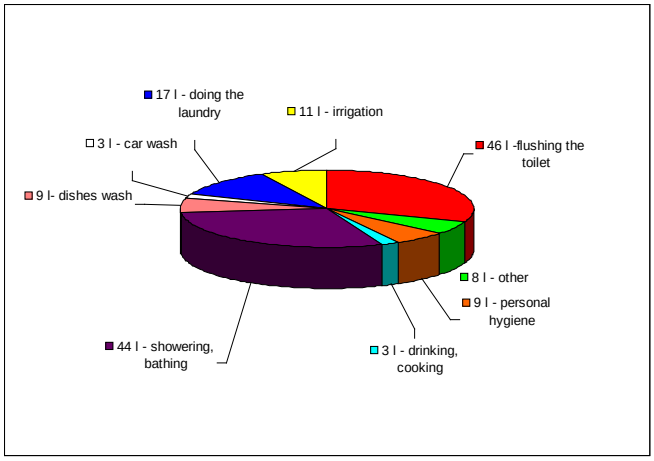


Fig. 1 average water consumption of a household (average consumption 150 l/(person per day))

II. Experimental Research in the Campus of TU Košice

The project APVV SUSPP-0007-09 relating to quality and quantity of rainwater, taking place at the Faculty of Civil Engineering in Košice-city. The sources tested are located in the premises of TUKE (Technical University of Kosice). The resources that provide us information about the quality and quantity of rainwater are located in the campus of Technical University of Kosice. First is rain gauge (Figure 2) located on the roof of University library and second is real school building PK6. All rainwater runoff from roof of this building is flow into the two infiltration shafts (Figure 3). Roof area of the PK6 building is 548,55 m^2(Figure 4).

This work was supported by the VEGA 1/0450/12 Energy balance research on rainwater management in the cities of the future.

The Centre was supported by the Slovak Research and Development Agency under the contract No. SUSPP-0007-09.

Ing. Gabriel Markovič, PhD., Technical University of Košice, Faculty of Civil Engineering, Institute of Architectural Engineering, Vysokoškolská 4, 042 00 Košice, mail: gabriel.markovic@tuke.sk

Ing. Daniela Kaposztásová, PhD., Technical University of Košice, Faculty of Civil Engineering, Institute of Architectural Engineering, Vysokoškolská 4, 042 00 Košice, mail: daniela.ocipova@tuke.sk

doc. Ing. Zuzana Vranayová, PhD., Technical University of Košice, Faculty of Civil Engineering, Institute of Architectural Engineering, Vysokoškolská 4, 042 00, Košice, e-mail: zuzana.vranayova@tuke.sk.

Fig. 2 rain gauge on the roof of University library

Fig. 3 location of infiltration shafts near building PK6

Both infiltration shafts are located at the east side of the building PK6. The shafts are realized from concrete rings with the outer diameter of 1000 mm. The measuring devices that provide us information about volume of incoming rainwater from the roof of the building PK6 and also information about the quality of rain water are located in these infiltration shafts [9].

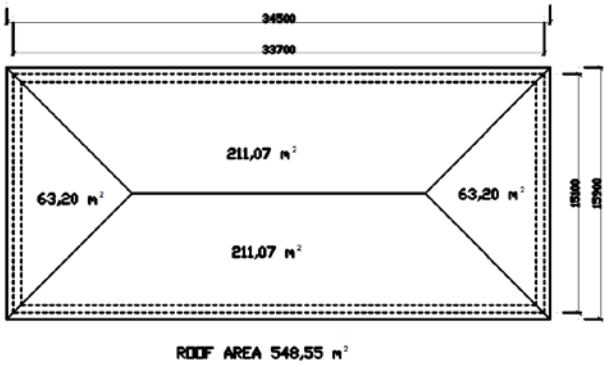


Fig. 4: Ground plan of PK6 roof

A. Measuring devices

Headquarters, respectively a control/data unit for generating of measurement data, is a universal data unit M4016, which is situated in the infiltration shaft A (Figure 5). Infiltration shaft B, respectively devices located in this shaft, are also connected to the control unit.

Fig. 5 data unit M4016 in shaft A

Registration and control unit equipped unit M4016 includes universal data logger, telemetric station with build-in GSM module, programmable control automat and multiple flow meter if M4016 is connected to an ultrasonic or pressure level sensor (Figure 5) [8].

Under inflow, respectively rain outlet pipe in the shaft, there are measurement flumes for metering of inflow rainwater from the roof of a building PK6 in both of infiltration shafts. Rainwater from the roof of the building PK6 is fed by rainwater pipes directly into measurement flumes, which are placed under the ultrasonic level sensor which transmitting data of the water level in the measurement flumes to the data unit M4016 (Figure 6).

The unit M4016, in which the signal transmitted from the ultrasonic level sensor is preset up to 14 equations or the most used sharp crested weirs. Flow rate calculation from relationship water level/flow rate. For the purposes of our measurements is to calculate the instantaneous and cumulative flow, calculated from water level used by predefined profile - Thomson weir.

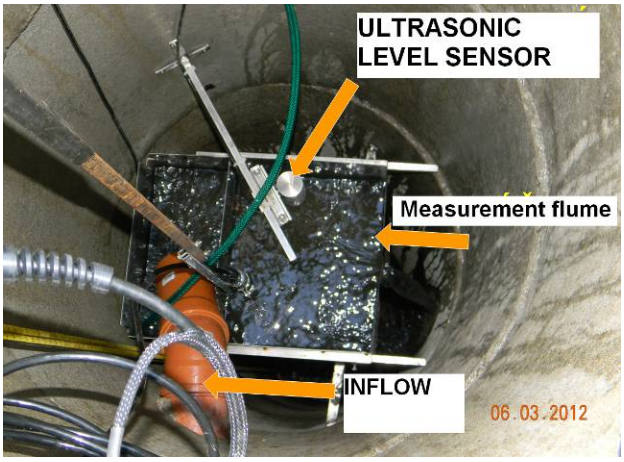


Fig. 6 measurement flume with ultrasonic level sensor in shafts [9].

Thomson weir consists of two overflow edges with an angle of 90°. Axis of this angle must be vertical (Figure 7) [4].

ISBN: 978-1-61804-224-8

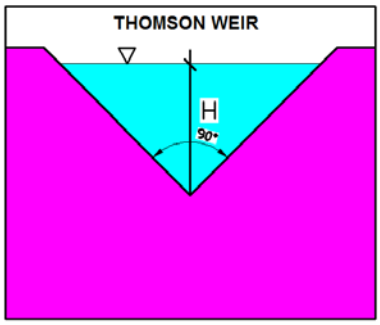


Fig. 7: Thomson weir

III. Analysis of System Design Uses Rainwater for Water Supply

Totals of rainfall represent the theoretical amount of rainfall in mm, falling on surface of interest. Totals of rainfall depend on specific locations.

The average of yearly totals of rainfall is about 770 mm/year in Slovakia.

In general, the rainwater harvesting system depends on:

- Required volume of water
- The amount of precipitation
- The size of roof or another catchment surfaces

A. Water demand in PK6 building

As already mentioned above, the research is done in the area of Kosice - at the campus of Technical University of Košice. Mentioned PK6 building is one of the buildings at the campus of Technical University of Košice with two infiltration shafts for rainwater runoff. All rainwater runoff from roof of this building is flow into the two infiltration shafts where are located the measuring devices for measuring the inflow volume of rainwater. Therefore, our analysis can be processed for this building.

The PK6 building has 20 employees and learning capacity is for 401 students. We will consider using rainwater only for flushing toilets for students 6 l/day and staff 12 l/day [3]. Considered daily water demand for students will be 30% of maximum capacity. Table 1 shows the calculated daily water demand for flush the toilet in building PK6 and Table 2 summarized monthly water demand.

Tab. 1 daily water demand in PK6 building

Water demand for flush the toilet in PK6 building Q_{wc}			
employees	20 pers.	12 l/pers.day	240 l/day
students	120 pers.	6 l/pers.day	720 l/day
			960 l/day
			0,96 m^3/day

Tab. 2 monthly water demand in PK6 building

Water demand for flush the toilet in PK6 building			
Month	Working days	Q_{wc} (m^3/day)	Q_{wc} (m^3/month)
January	20	0,96	19,2
February	20	0,96	19,2
March	23	0,96	22,08
April	19	0,96	18,24
May	22	0,96	21,12
June	22	0,96	21,12
July	20	0,96	19,2
August	22	0,96	21,12
September	20	0,96	19,2
October	21	0,96	20,16
November	20	0,96	19,2
December	21	0,96	20,16
			240 m^3/year

Initial measurements start and continue in infiltration shaft A since March 2011, when began to measure the inflow of rainwater runoff from the part (212 m^2) of roof of the building PK6. Table 3 represents the measured volumes of rainwater from the roof area of 212 m^2 of PK6 building.

In March 2012, the research was extended of measurements of rainwater quantity in infiltration shaft B. It provides us data of rainwater quantity from all roof area (548,55m^2) of PK6 building. Table 4 represents the measured volumes of rainwater from all roof area 548,55m^2 of PK6 building. (Notice: august 2012 without data due to equipment failure)

Tab. 3 volume of rainwater inflow to Shaft A – from 212 m^2 of roof

Date	**Volume of rainwater inflow to Shaft A – from 212 m^2 of roof (m^3)**
March 2011	7,38
April 2011	1,47
May 2011	23,29
June 2011	23,45
July 2011	36,18
August 2011	6,47
September 2011	3,97
October 2011	3,23
November 2011	0
December 2011	9,75
January 2012	3,22
February 2012	0,32
March 2012	14,48

ISBN: 978-1-61804-224-8

Tab. 4 volume of rainwater inflow to both shafts – from all roof area 548,55m^2

Date	Volume of rainwater inflow to both shafts A+B from all 548,55m^2 of roof (m^3)
April 2012	26,72
May 2012	10,91
June 2012	40,75
July 2012	41,56
August 2012	-
September 2012	17,93
October 2012	36,47
November 2012	16,94
December 2012	12,05
January 2013	17,92
February 2013	15,5
March 2013	16,77
April 2013	9,77
May 2013	30,55
June 2013	30,17
July 2013	36,63
August 2013	3,78
September 2013	8,94
October 2013	13,72
November 2013	38,39
December 2013	1,27

Tab. 5 volume of rainwater inflow to both shafts – from roof area 212 m^2

Date	Q_{wc} (m^3/month)	Real volume inflow (m^3)	excess/lack of water (m^3)
March 2011	22,08	7,38	-14,7
April 2011	18,24	1,47	-16,77
May 2011	21,12	23,29	+2,17
June 2011	21,12	23,45	+2,33
July 2011	19,2	36,18	+16,98
August 2011	21,12	6,47	-14,65
September 2011	19,2	3,97	-15,23
October 2011	20,16	3,23	-16,93
November 2011	19,2	0	-19,2
December 2011	20,16	9,75	-10,41
January 2012	19,2	3,22	-15,98
February 2012	19,2	0,32	-18,88
March 2012	22,08	14,48	-7,6

Table 5 represents the measured volumes of rainwater from the roof area (212 m^2) of PK6 building compared with the water demand for flush toilets. From Table 5 shows that, although this is not volume of rainwater from all roof area, water demand is ensured in some months.

Table 6 contains the measured volumes of rainwater from the all roof area of PK6 building compared with the water demand for flush toilets.

Tab. 6 volume of rainwater inflow to both shafts – from all roof area 548,55m^2

Month	Q_{wc} (m^3/month)	Real volume inflow (m^3)	excess/lack of water (m^3)
April 2012	18,24	26,72	+8,48
May 2012	21,12	10,91	-10,21
June 2012	21,12	40,75	+19,63
July 2012	19,2	41,56	+22,36
August 2012	21,12	-	-
September 2012	19,2	17,93	-1,27
October 2012	20,16	36,47	+16,31
November 2012	19,2	16,94	-2,26
December 2012	20,16	12,05	-8,11
January 2013	19,2	17,92	-1,28
February 2013	19,2	15,5	-3,7
March 2013	22,08	16,77	-5,31
April 2013	18,24	9,77	-8,47
May 2013	21,12	30,55	+9,43
June 2013	21,12	30,17	+9,05
July 2013	19,2	36,63	+17,43
August 2013	21,12	3,78	-17,34
September 2013	19,2	8,94	-10,26
October 2013	20,16	13,72	-6,44
November 2013	19,2	38,39	+19,19
December 2013	20,16	1,27	-18,89

Figure 8 represents a graph for number of possible toilet flush with rainwater inflow from roof of PK 6 building per month from March 2011 to December 2013 what is the amount of drinking water saved in the building PK6. Water consumption per one flush is 6 liters.

ISBN: 978-1-61804-224-8

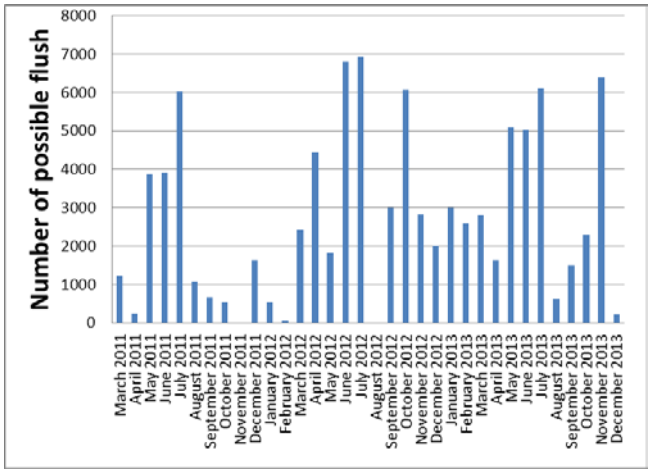


Fig. 8 number of possible toilet flushes per month from March 2011 to December 2013 in PK6 building

B. Rainfall intensity and catchment surface

As already mentioned above, the research is done in the area of Kosice. Figure 9 represents a graph of annual precipitation for the Kosice-city [5] in the years 1900 to 2010, with an average value of annual precipitation for this period about 638 mm/year.

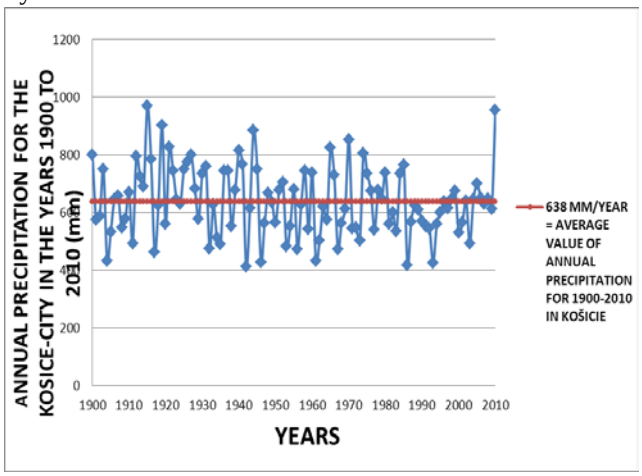


Fig. 9 annual precipitation for the Kosice in the years 1900 to 2010 [5]

Intensity of rainfall in combination with rooftop area or another paved surface will determine maximum volume of rainwater possible to capture and accumulate. Determination of the theoretical volume of rainwater from the catchment area can be determined by the equation:

$$V_{rain} = z_{year}.A.C \quad (1)$$

Where:

V_{rain} – theoretical volume of rainwater

z_{year} – average yearlong precipitation depth for chosen locality (mm/year),

A – roof or another catchment area (m^2),

C – runoff coefficient (non–dimensional coefficient).

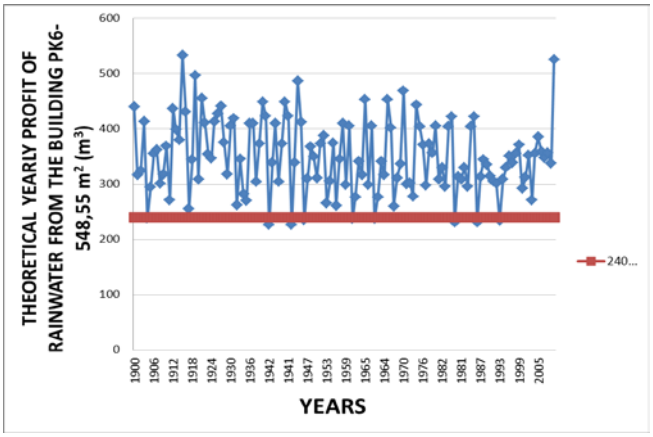


Fig.10 theoretical yearly profit of rainwater from the roof area 548,55 m2 of PK6 building against water demand 240 m^3/year in the years 1900 to 2010

If we consider the surface of the roof of the building PK6 548,55m^2, figure 10 shows the theoretical yearly volume of rainwater. Runoff coefficient was considered C=1, according to Slovak standard STN 73 6760 (table 7) [6].

According to yearly precipitation from the years 1900-2010 for the city of Kosice is apparent that the water demand 240 $m^{3/}$year for toilet flush in PK6 building would be fulfilled in most of years (Figure 10).

Tab. 7 runoff coefficient according to Slovak standard STN 73 6760

Type of drained surface	**Runoff coefficient C (-)**
Rooftops, balconies, roof decks [a)]	1,0
Rooftops with permeable surface thicker than 100 mm	0,5
[a)] Rainwater drainage coefficient C = 0,8 can be used for rooftops with area over 10 000 m^2	

However, a more accurate view provides analysis of monthly precipitation totals. As already mentioned above, one resource that provides us information about quantity of rainwater is rain gauge located in the campus of Technical University of Kosice on the roof of University library. Figure 11 represents a graph of measured values of rainfall during our research from August 2011 to December 2013.

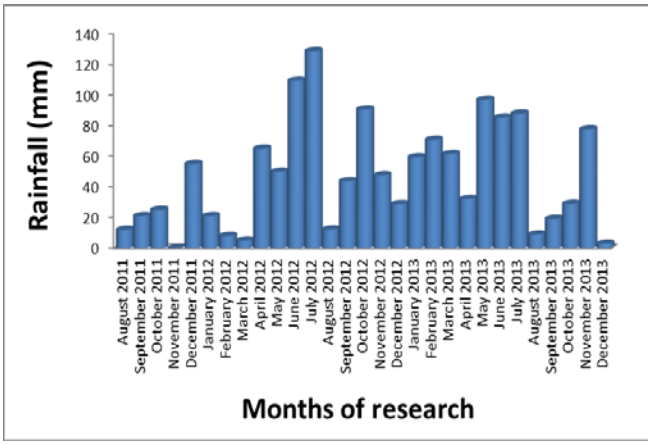


Fig. 11 graph of measured values of rainfall during our research

Table 8 summarizes the measured monthly rainfall totals with corresponding theoretical volumes of collected rainwater. Data are presented for the period April 2012 to December 2013 because at that time began measuring of the flow from all roof area of the building PK6 and precipitation measurements simultaneously.

Tab. 8 theoretical volume of rainwater from PK6 building (548,55m^2) according to the measured values of precipitation from April 2012 to december 2013

Month	Rainfall (mm)	Theoretical volume from 548,55 m^2(m^3)
April 2012	65	35,65
May 2012	50	27,42
June 2012	109	60,01
July 2012	129	70,65
August 2012	12	6,69
September 2012	44	24,02
October 2012	91	49,69
November 2012	48	26,11
December 2012	29	15,79
January 2013	59	32,58
February 2013	71	38,83
March 2013	62	33,79
April 2013	32	17,66
May 2013	97	53,20
June 2013	85	46,84
July 2013	88	48,27
August 2013	9	4,93
September 2013	19	10,53
October 2013	29	15,90
November 2013	78	42,56
December 2013	3	1,64

Tab. 9 measured monthly rainfall totals with corresponding theoretical volumes of collected rainwater and real amount of rainwater from roof of PK6 building (548,55m^2)

Month	Rainfall (mm)	Teoretical volume from 548,55 m^2(m^3)	Real volume from 548,55 m^2(m^3)	%
April 2012	65	35,65	26,72	**74,9**
May 2012	50	27,42	10,91	**68,8**
June 2012	109	60,01	40,75	**67,9**
July 2012	129	70,65	41,56	**70,1**
August 2012	12	6,69	-	**-**
September 2012	44	24,02	17,93	**74,6**
October 2012	91	49,69	36,47	**73,4**
November 2012	48	26,11	16,94	**64,9**
December 2012	29	15,79	12,05	**76,3**
January 2013	59	32,58	17,92	**61,1**
February 2013	71	38,83	15,5	**60,5**
March 2013	62	33,79	16,77	**67,4**
April 2013	32	17,66	9,77	**66,6**
May 2013	97	53,20	30,55	**57,4**
June 2013	85	46,84	30,17	**64,4**
July 2013	88	48,27	36,63	**75,9**
August 2013	9	4,93	3,78	**76,6**
September 2013	19	10,53	8,94	**84,9**
October 2013	29	15,90	13,72	**86,2**
November 2013	78	42,56	38,39	**90,2**
December 2013	3	1,64	1,27	**77,2**

Table 9 summarizes the real measured monthly rainfall totals with corresponding theoretical volumes of collected rainwater and real amount of rainwater from roof of PK6 building. The last column represents the percentage of the real volume of inflow rainwater compared with values from theoretical calculation.

IV. Conclusion

One of the methods of effective use of potable water sources used more frequently nowadays, not only in industrial but also in developing countries, is rainwater harvesting from surface runoff (RHSR). Application of RHSR system reduces ecological mark of a building and establishes conditions for permanent future sustainable development [7].

The aim of this article is to analyze the possible use of

rainwater in the real building and description of the tools what we use at the campus of TUKE for obtaining the necessary data. As is apparent from the data in tables and graphs, planned use of rainwater in the building is not sufficient in all months. Of course, the possible volume of rainwater is dependent on the intensity of rainfall and roof area. Measured data volumes of rainwater from the roof structure in real conditions also shows that real values are lower than those obtained by the theoretical calculation. Therefore, it is preferable to design the system for rainwater harvesting with a lower coefficient of runoff as C = 1. It may increase the accuracy of system design in real conditions.

The main goal for rainwater harvesting system design should not be full coverage of water demand for a specific purpose in building. The main goal should be to design of these systems as an alternative source of water. This would avoid of wasting precious drinking water which is used for example - for flushing toilets.

REFERENCES

[1] P.J. Coombes, G. Kuczera, J. Argue, J.D. Kalma, "An evaluation of the benefits of source control measures at the regional scale," Urban Water, vol. 4 (4), 2002a, pp. 307-320.

[2] V.G. Mitchell, R.G. Mein, T.A. Mcmahon,"Evaluating the resource potential of stormwater and wastewater an Australian perspective," Australian Journal of Water Resources, vol. 2(1), 1997, pp. 19–22.

[3] P. Hlavínek,"Hospodaření s dešťovými vodami v urbanizovaném území," ARDEC s.r.o., ISBN 80-86020-55-X, 2007.

[4] V. Mosný, Hydrológia - Morfológia povodia a prietoky. Bratislava, vydavateľstvo STU, ISBN 80-227-1782-7.

[5] H. Hlavatá, "The analysis of changes of atmospheric precipitation in Košice in the years 1900 – 2005," Slovenský hydrometeorologický ústav Bratislava, Regionálne stredisko Košice.

[6] STN EN 73 6760: Kanalizácia v budovách

[7] A Master Framework for UWCS Sustainability (April, 2013), Available: http://www.trust-i.net

[8] Technické podklady Fiedler-magr – Manuál M4016.

[9] G. Markovič: Trvalo udržateľné nakladanie so zrážkovými vodami z povrchového odtoku pri odkanalizovaní budov, Thesis,Košice 2012.

Gabriel Markovič is researcher at the Faculty of Civil Engineering, Technical University in Kosice. He is specialised in Water supply and drainage systems. Recently he has been concentrated on the field of rainwater harvesting and rainwater infiltration systems.

Daniela Kaposztasova is lecturer at the Faculty of Civil Engineering, Technical University in Kosice. She is specialised in Water supply and drainage systems. Recently she has been concentrated on the field of hot water distribution systems and rainwater reuse.

Zuzana Vranayova is the professor at the Civil Engineering Faculty, Technical University in Kosice, Department of Building Services. She is conducting various researches on her major field of study of water supply and drainage system in buildings. She is also actively involved in governmental and academic institutions and committees related to her field of study as chief coordinator and board member. She is a vice dean for education

The problem of prediction of temperature changes within the industrial dumps

Blanka Filipova

***Abstract*—**The paper deals with the prediction of the behavior fires in mine dumps and industrial waste dumps. The results of measurements of temperature, concentration of dangerous gases and atmospheric variables on the mine dump Hedvika in Petrvald are presented. Design of prediction algorithm of the temperature is discussed as well as the influence of atmospheric variables on the course of the temperature inside the mine dump.

***Keywords*—**industrial dumps, measurement, prediction, regression.

I. Introduction

THE issue of mining dumps is very extensive. The heaps are made from waste and tailings from coal mines. Waste rocks can catch fire spontaneous at any time and mining dump starts to burn. Temperatures can change immediately. Fast change of temperature has a bad effect on the environment, whether it is the fauna, flora, or the surrounding buildings and humans. CO and CH_4 occur as a secondary product of combustion. It is dangerous for living organisms. For this reason, the presented data model is developed. The data model primarily monitors temperature changes in the mining dump. It is a large network made up of tens of sensors. The sensors measure temperature at a depth of 3 and 6 meters. Temperature distribution throughout the heap is determined with using mathematical interpolated methods based on the temperature measurements. The temperature changes are predicted with using extrapolation techniques.

II. Analytic model

Mathematical theory of heat conduction allows the general expression of the differential equation of heat conduction. This is probably the best known examples of partial differential equations of parabolic type, known as Fourier heat equation (1), which can in unsteady heat conduction express the thermodynamic temperature T (.) depending on the time coordinate t and the spatial coordinates.

Fourier heat equation

$$\rho \cdot c \cdot \frac{\partial T}{\partial t} = -\left\{\frac{\partial}{\partial x}\left(-\lambda_x \cdot \frac{\partial T}{\partial x}\right) + \frac{\partial}{\partial y}\left(-\lambda_y \cdot \frac{\partial T}{\partial y}\right) + \frac{\partial}{\partial z}\left(-\lambda_z \cdot \frac{\partial T}{\partial z}\right)\right\} + \dot{Q}_V''' \quad (1)$$

where

T	temperature	[K]
t	time	[s]
ρ	density	[kg · m-3]
c	specific heat capacity	[J · kg-1 · K-1]
λ	Coefficient of thermal conductivity	[W · m-1 · K-1]
$\dot{Q}_V$	volumetric heat source	[W · m-3]

In the case of the symbol $\dot{Q}_v$ we talking about the internal volumetric heat source in a given volume element, then

$$\dot{Q}_v = \dot{Q}_V''' \cdot \Delta x \cdot \Delta y \cdot \Delta z = \dot{Q}_V''' \cdot dx \cdot dy \cdot dz \quad (2)$$

In the Fourier equation can not assume that the coefficients are temporally or spatially constant or isotropic.

III. Results of measurement

The distribution of probes is shown in Fig. 1. The probes are made using thick-walled tube with an outer diameter 40 mm, placed in a depth 6 m below the ground level. After a thorough analysis the analog temperature sensors type Pt100 were selected. The probes S2, S4 and C7 were chosen for experimental evaluation of the measured data. Temperature is measured by 24 sensors at intervals of 10 minutes. Measured data are stored in a database and then using the interpolation and extrapolation techniques processed. Measured temperatures on Fig. 2 date from the period 18.6 – 18.7. 2013.

This work was supported by project TA01020282, ”Enhancement of quality of environment with respect to occurrence of endogenous fires in mine dumps and industrial waste dumps, including its modeling and spread prediction,” of Technology Agency of the Czech Republic and by project SP2014/156, “Microprocessor based systems for control and measurement applications,” of Student Grant System, VSB-TU Ostrava.

B. Filipova is with Department of Cybernetic and Biomedical Engineering. VSB - Technical University of Ostrava, Czech Republic, (phone +420 597323229;email: blanka.filipova@vsb.cz)

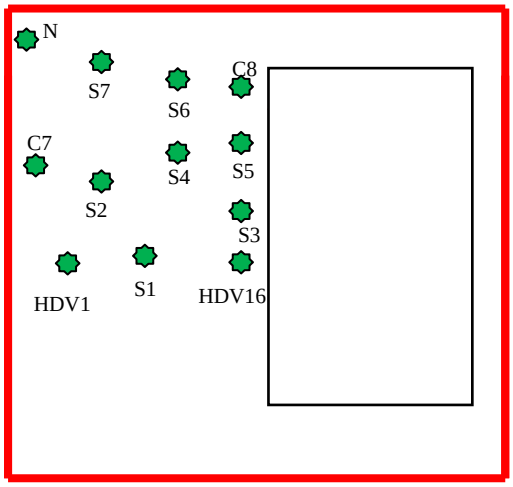


Fig. 1 Measuring polygon for mine dump Hedvika. The location of the probes.

In the course of the project the investigators struggled and had to deal with a number of negative impacts and their consequences, especially in the area of the temperature sensor, the signal lines, communication lines etc. The major problems causing the temperature along with the aggressive environments in measuring probes. In the course of monitoring there were damaged or completely destroyed particular signal wires from the sensors to the telemetry unit, occurred even in cases of complete destruction of the actual sensor type Pt100.

	Correlation coefficiens			Regression	
Probe	**S2**	**S4**	**C7**	**Linear part**	**Absolute part**
	3 m	3 m	3 m	k	y
S2	1	0,523	0,9105	0,1039	-76361,0883
S4	0,523	1	0,6968	0,011	-8058,5633
C7	0,9105	0,6968	1	0,0612	-44986,4036

Tab. 1 The correlation coefficients and regression coefficients for probe S2, S4 and C7 at a depth of 3m. The period 18.6 – 18.7. 2013

	Correlation coefficiens			Regression	
Probe	**S2**	**S4**	**C7**	**Linear part**	**Absolute part**
	3 m	3 m	3 m	k	y
S2	1	0,6872	0,8009	-0,037	27208,6509
S4	0,6872	1	0,892	-0,0191	14073,8567
C7	0,8009	0,892	1	-0,0264	19429,9866

Tab. 2 The correlation coefficients and regression coefficients for probe S2, S4 and C7 at a depth of 6m. The period 18.6 – 18.7. 2013

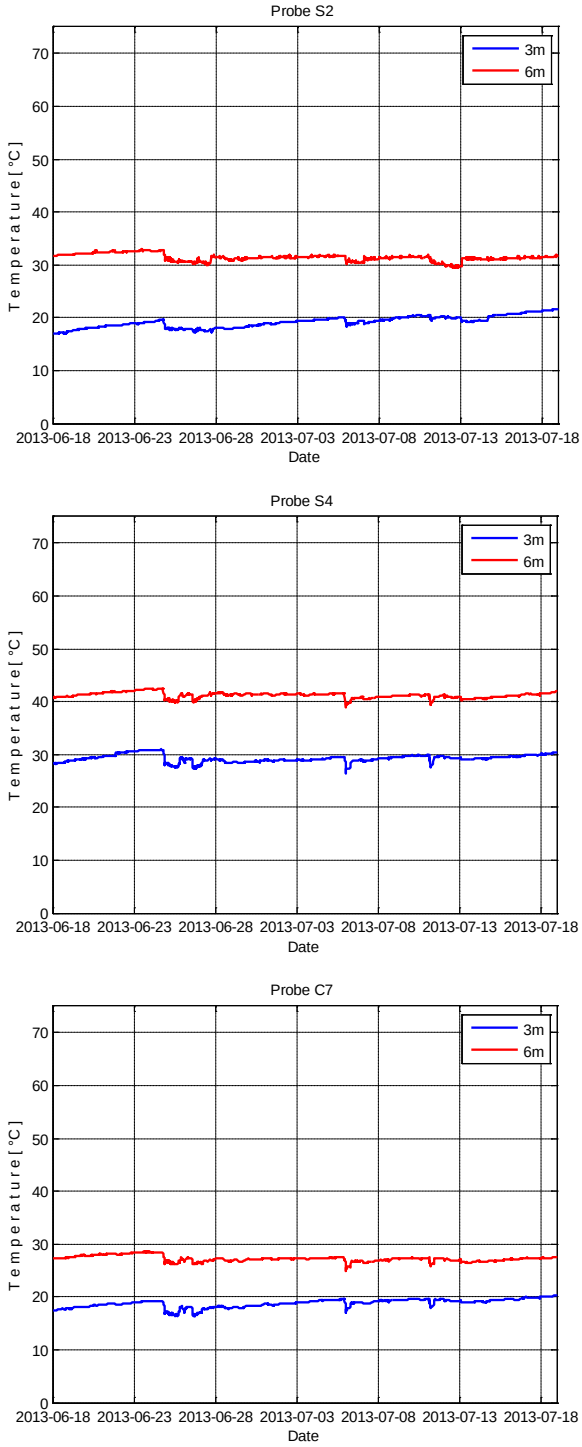


Fig. 2 The measured temperature curves in the probes S2, S4 and C7 date from the period 18.6 – 18.7. 2013

On the basis of the regression lines, calculated correlation and regression coefficients (Tab.1 to Tab.2) it can be considered as non-stationary system, and therefore can not be assumed nor time invariance and nor linearity.

ISBN: 978-1-61804-224-8

The heap is a nonlinear time-varying object that changes its properties in a random process, defined as in the time so in the space independent variable.

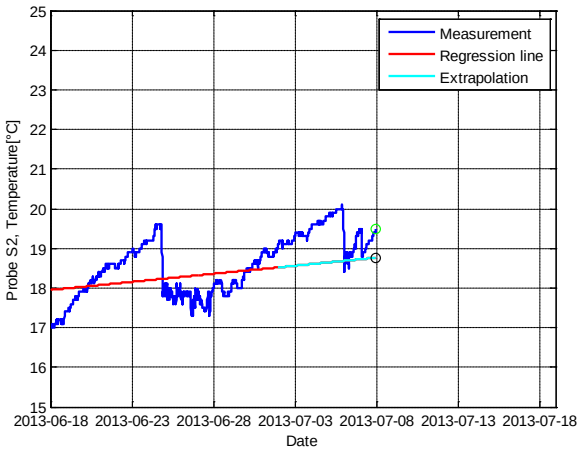
The essence of this randomness is undefined material and structural composition of the heap and heap porosity. This is caused by undefined and unpredictable combusting residues of coal and associated gas. Composition and structure of the heap so from the viewpoint of the observer changes randomly in time.

IV. Prediction

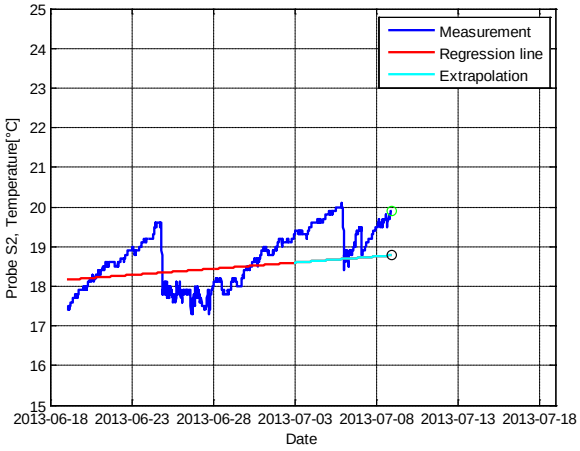
Suppose it is determined by linear regression line for the last known 14 days. The criterion is the minimum sum of squared deviations of hourly averages of measured values during this period. Found dependency is extrapolated to a subsequent period of six times 24 hours (i.e., 144 hours). After this six-day period of measurement values the mean square error as the root mean square deviation for the entire forecast period is determined.

In Fig. 3, the measured data is shown in blue, the regression line is red and light blue color indicates the progress of the predicted regression line.

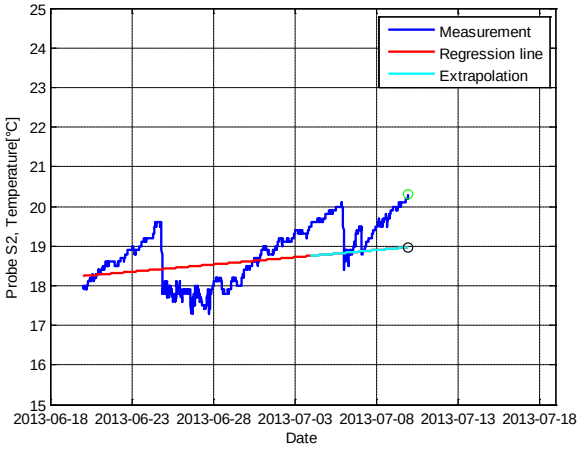
A) 1 Data segment



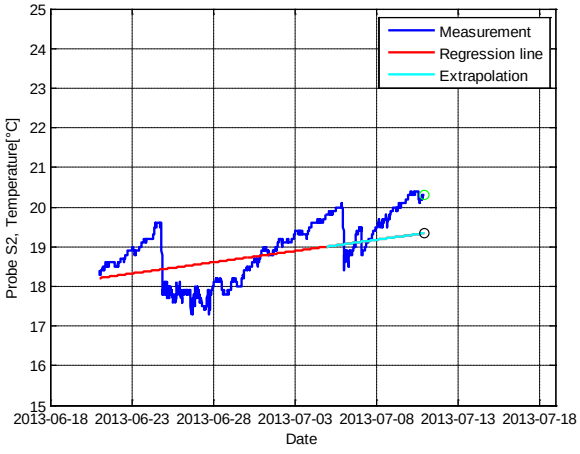
B) 2. Data segment



C) 3. Data segment

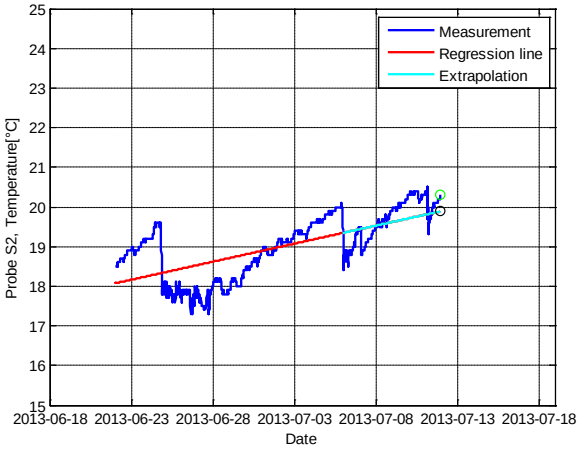


D) 4. Data segment

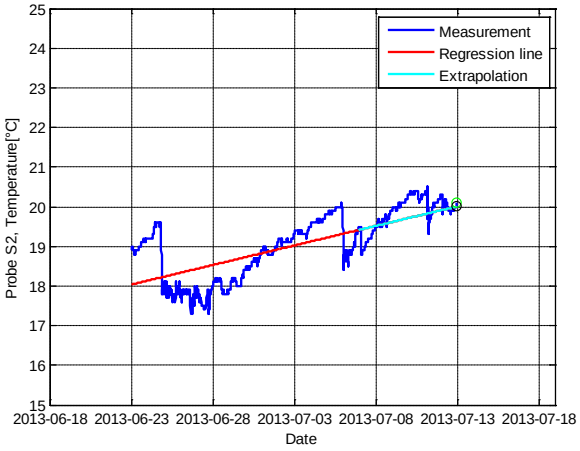


ISBN: 978-1-61804-224-8

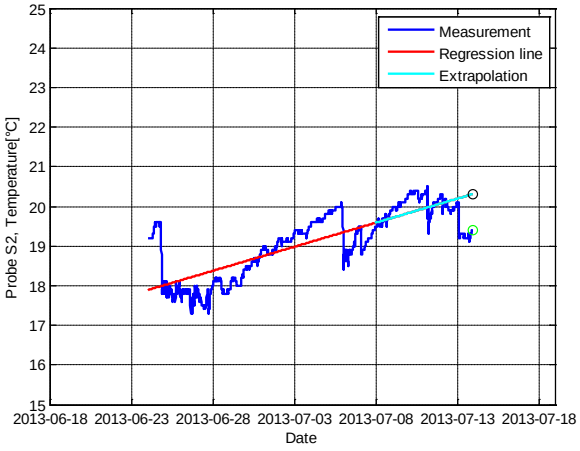
E)5. Data segment



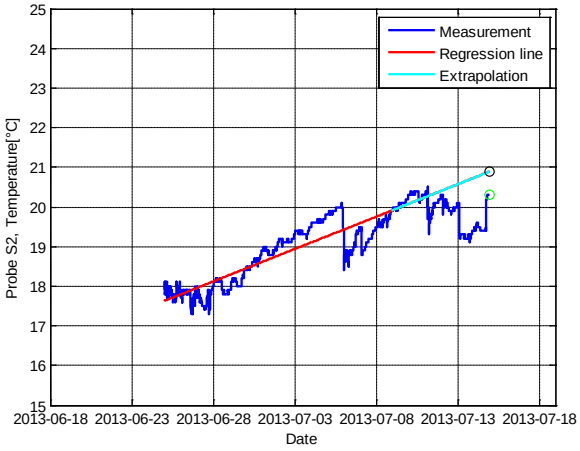
F)6. Data segment



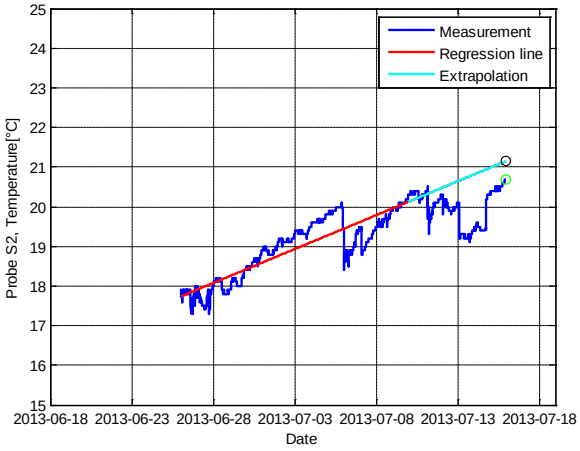
G) 7. Data segment



H) 8. Data segment



I) 9. Data segment



J) 10. Data segment

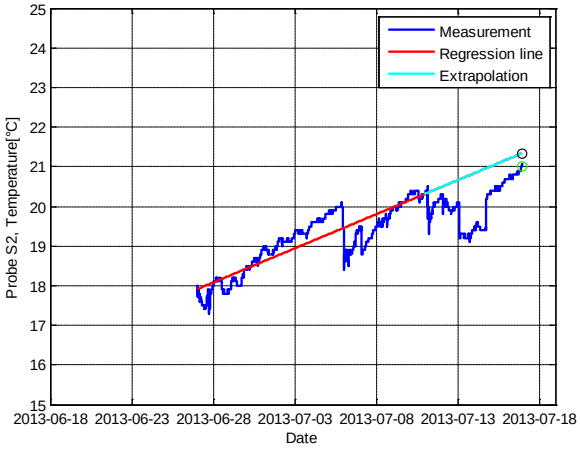


Fig. 3 Regression line and extrapolation. The period 18.6 – 18.7. 2013. The depth of 3 m, probe S2, horizon 6 days, 10 data segments.

ISBN: 978-1-61804-224-8

Data segment	The mean square deviations of the measured data relative to the regression line		
	the entire measurement curve	predicted part	part used for prediction
#1	0,4372	0,6604	0,3413
#2	0,4319	0,7227	0,3072
#3	0,4267	0,6725	0,3213
#4	0,3925	0,4646	0,3617
#5	0,3231	0,1628	0,3918
#6	0,3004	0,1246	0,3757
#7	0,2759	0,2107	0,3038
#8	0,2753	0,5984	0,1366
#9	0,3125	0,7308	0,1329
#10	0,3291	0,7894	0,1314

Tab. 3 The mean square deviations of the measured data relative to the regression line. The period 18.6 – 18.7. 2013. The depth of 3 m, probe S2, horizon 6 days, 10 data segments.

V. The Influence of Atmospheric Variables on Temperature in the Heap

The atmospheric variables were measured too. Their influence on the measured temperature of mining dump was monitored. Fig. 4 demonstrates progress of the measured atmospheric variables as humidity, ambient temperature and light exposure.

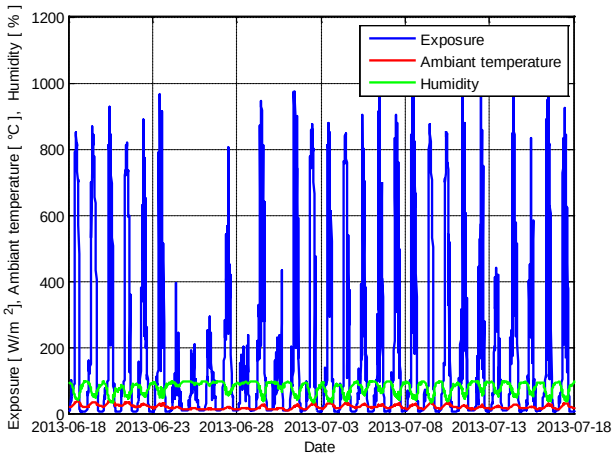


Fig. 4 Atmospheric variables.

Correlation coefficients between temperature of probe S2 in depth 3m and atmospheric variables are shown in the following tables Tab. 4.

Correlation coefficiens				
	S2	**Exposure**	**Ambient temperature**	**Humidity**
S2	1	0,0219	0,0416	-0,1068
Exposure	0,0219	1	0,6926	-0,781
Ambient temperature	0,0416	0,6926	1	-0,8777
Humidity	-0,1068	-0,781	-0,8777	1

Tab. 4 Correlation coefficients between the temperature in probe S2, in depth 3m and atmospheric variables.

As seen from the results of the correlation coefficients the influence of atmospheric variables on instantaneous value of the temperature at a depth of 3 m is not significant. Statistically significant is the dependence of the ambient temperature and humidity on exposure and dependence humidity on the ambient temperature.

VI. Conclusion

The paper dealt with most frequently used method of extrapolation. This method was applied to data measured on the mining dump Hedvika. The created model is used for long-term monitoring of temperatures in the mining dump.
We conclude that the prediction algorithm follows slow temperature change. If the heap does not unexpected outburst of accumulated material, the development of the temperature due to the weight of the heap is slow. The design and implementation of measurement provide sufficient input information and linear prediction algorithm implements a six-day forecast with the mean accuracy about 1.5 degrees Celsius. It is close to the accuracy of the temperature measurement accuracy heap. If the heap sudden changed the temperature the prediction algorithm does not have enough information to make this change predicted and captured. Based on the analysis of the effect of atmospheric variables has been found that these variables have no significant effect on the temperature changes in the heap.

Acknowledgment

Article was supported by project TA01020282, ”Enhancement of quality of environment with respect to occurrence of endogenous fires in mine dumps and industrial waste dumps, including its modeling and spread prediction,” of Technology Agency of the Czech Republic and by project SP2014/156, “Microprocessor based systems for control and measurement applications,” of Student Grant System, VSB-TU Ostrava.

REFERENCES

[1] G.M. Phillips, P. J. Taylor, *Theory and Aplications of Numerical Analysis*. Elsevier Academic Press. London,1996. ISBN 0-12-553560-0

[2] B. Filipova, R. Hajovsky, "Using MATLAB for modeling of thermal processes in a mining dump". Recent advances in fluid mechanics and heat & mass transfer. Proceedings of the 9th IASME/WSEAS International Conference on Heat Transfer, Thermal Engineering and Environment. Florence, Italy, WSEAS Press, 2011, pp. 116-119. ISBN 978-1-61804-026-8.

[3] S. Ozana, R. Hajovsky, M. Pies and B. Filipova," Modeling and Measurement of Thermal Process in Experimental Borehole in Matlab&Simulink and Comsol Multiphysics". In: Advances in Systems Theory, Signal Processing&Computational Science: Proceedings of the 12th WSEAS International Conference on Systems Theory and Scientific Computation (ISTASC'12). Istanbul, Turkey: WSEAS Press, 2012, s. 84-89. Recent Advances in Electrical Engineering Series, 5. ISBN 978-1-61804-115-9. ISSN 1790-5117.

[4] R. Hajovsky, S. Ozana, P. Nevriva, "Remote Sensor Net for Wireless Temperature and Gas Measurement on Mining Dumps". In ZAHARIM, Azami, et al. Recent Researches in Applied Informatics&Remote Sensing : Proceedings of the 7th WSEAS International Conference on Remote Sensing. Penang,Malaysia : WSEAS Press, 2011. s. 124-128. ISBN 978-1-61804-039-8.

[5] R. Hajovsky, B. Filipova, M. Pies and S. Ozana. Using Matlab for thermal processes modeling and prediction at mining dumps". In: ICCAS 2012: Proceedings of the 12th International Conference on Control, Automation and Systems. ICC, Jeju Island, Korea, s. 584-587. ISBN 978-89-93215-04-5 95560. ISSN 2093-7121. (2)

[6] B. Filipova, R. Hajovsky and S. Ozana, "Processing and Visualization of Measured Data on the Mining Dump". In: Advances in Systems Theory, Signal Processing&Computational Science: Proceedings of the 12th WSEAS International Conference on Systems Theory and Scientific Computation (ISTASC'12). Istanbul, Turkey: WSEAS Press, 2012, s. 57-61. Recent Advances in Electrical Engineering Series, 5. ISBN 978-1-61804-115-9 ISSN 1790-5117.

[**7**] **J.** STOER, R. BULIRSCH, " Introduction to numerical analysis". Springer science + business media, New York, USA, 2002. ISBN 978-0-387-95452-3

[8] E. Vitasek, "Numericke metody". SNTL, Praha 1987.

[9] L. Lixin, P. Revesz, "Interpolation methods for spatio-temporal geographic data". Computers Environment and Urban Systems. Volume 28, Issue 3, pages 201 – 227, 2004. Elsevier.

Assessing *Chenopodium album L.* potential for phytoremediation of lead-polluted soils

A. Nazli Alipour,B. Mehdi Homaee,C.Safoora Asadi Kapourchaland D. mahboobeh Mazhari

***Abstract*—**The objective of this study was to investigate the capability of *Chenopodium album L*. to remediate lead polluted soils. For this purpose, a randomized block experiment design was performed. The soil was contaminated with $PbNO_3$ and the treatments were consisted of 0 (standard), 150, 300, 600, 900 and 1200 mg/kg lead. After development, plants were harvested and divided into shoot and root parts. The lead content of shoot, root and also the soil-lead were measured. The results indicated that by increasing the lead concentration in soil, its accumulation in plant tissues was also increased. By increasing lead concentration in the soil,the metal transport factor was decreased. According to the obtained results, the resistance index of *Chenopodium album L*. was more than 1. Therefore, concerning its resistant and its high biomass, halophyte *Chenopodium album L*. can be used as a hyperaccumulator plant to remediate lead polluted soils.

Keywords—Chenopodium album L, lead, phytoremediation, pollution

I.INTRUDOCTION

Phytoremedian is one of the newly proposed methods to remediate soils from heavy metals. In this method plants are used to clean up the contaminated soils [3]. Many investigations by several researchers were conducted on different aspects of phytoremediation [9]-[12]-[4]-[7]-[8]-[10]-[5]-[6]-[1]and all confirm that this technology is sustainable to clean up the contaminated soils, Although this method is inexpensive, efficient and environment-friendly, but it is a time-consuming method. The first recognized plants to accumulate heavy metals belonging to *Brassicaceae* and *Fabaceae* families [2]. The objective of this study was to investigate the capability of *Chenopodium album L*. to extract lead from contaminated soils with high content of Pb.

II. Material and methods

This research was conducted in a randomized block experimental design with six treatments and four replicates. The designed treatments were consisted of 150 (standard), 300, 600, 900 and 1200 mg/kg lead.To get some information about physical and chemical properties of the experimental soils, some soil samples wereair dried, mixed, passed through 2 mm sieve to measure their cadmium contents. Experiments including electricalconductivity of saturation extract was measured with a conductivity meter, soil organic matter concentration with WalkleyandBlackmethod, soil texture with hydrometer method**,** calcium carbonate content with titration method, bulk density with cylinder method, cation exchange capacity with cations situation with sodium acetate and soil pH was measured with with a pH meter. Table 1 gives some physical and chemical properties of the experimental soils.

Table 1. Some physical and chemical properties of the experimental soil

Soil texture	EC_e (dS/m)	O.M (%)	CaCO3 (%)	CEC (cmolc/kg)	pH	Bulk density (gr/cm^3)
Sandy clay loam	6.71	0.7	7.5	14	7.58	1.33

To contaminate the experimental soils, the soils were first thoroughly sprayed with PbNO3. Five other treatments including 150, 300, 600, 900 and 1200 mg/kg lead denoted as Pb2, Pb3, Pb4, Pb5, Pb6 were established withfour replicates for each treatment. To obtain chemical equilibrium between contaminant and soil and also to create natural contamination conditions,the experimental treatments with their replicates were left for 50 days, receiving enough water every 24 hours. When the chemical equilibrium between lead and soil was obtained, different lead forms in the soil treatments were measured. The soils were weighted about 7 kg for each pot and were carefully packed in the pots to obtain a uniform bulk density of 1.33 g/cm^3. After that the seeds were seeded in the pots. To prevent any water stress during the growth period, soil water content was always held at field capacity.

When plants were fully developed, plants were harvested and divided into shoot and root parts. Different chemical forms of lead concentrations in the soil were then measured with continuous extraction method [11]. The lead concentration in shoots and roots was measured by digestion with complex of nitric acid-perchloric acid and sulfuric acid with 1:4:40volume based and analyzed for Pb by ICP-ES apparatus.The soil lead concentration was measured, using theAtomic Absorption apparatus. Finally, the effect of soil lead concentration on lead absorbed by different parts of plant including shoot and roots was performed with statistical comparison of averages, using the Duncan's multiple range test method with SPSS software.

III.Results

Metal or metalloid transport factor is the amount of accumulated metal in shoot per amount of accumulated metal in root (shoot/root ratio). By increasing the lead concentration in the soil, the metal transport factor was decreased under 600 mg kg^{-1} soil Pb content, but from 600 to 1200 mg kg^{-1} soil Pb content, metal transport factor was increased, which was not considerable. The relationship between soil Pb concentrations and metal transport factoris presented in Fig. 1.

ISBN: 978-1-61804-224-8

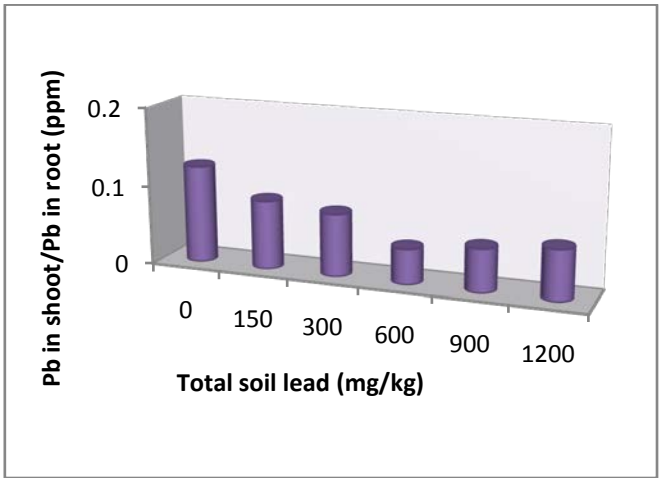


Fig. 1 Relationship between soil Pb concentrations and metal transport factor in plants

Phytoextractionefficiency determine with two key factors of hyperaccumulator plants capacity to heavy metal absorption and high biomass production. Though that this plant can accumulate lead in shoot and root but, its capability to phytoextraction process is depended on amount of produced dry matter.

To calculatethe relative performance, the plant dry weight in standard treatment was assumed to be equal to maximum dry weight of plant. Thus, relative performance was obtained by dividing dry weight of plants in various contaminated treatments to the maximum dry weight.Fig. 2 shows the influence of total soil lead on relative performance of plant.Byincreasing the lead concentration in soil, Plant yield (performance) was also increased and in 600 mg/kg lead treatment, the maximum yield was obtained. Thereafter, yield was decreased and this decreasing trend was continued until treatment of 1200 mg/kg lead. This decreasing trend was not considerable and plant yield in these levels was more than standard treatment.

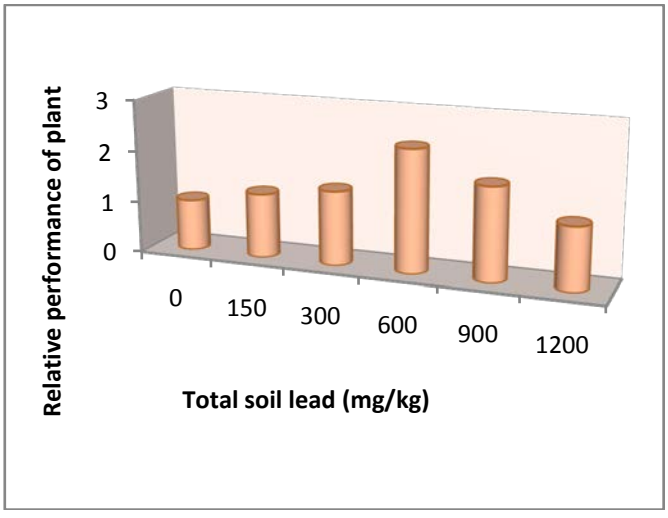


Fig. 2 Relative performance of plant in different soil Pb concentrations

The relationship between soil Pb concentrations and lead removal by shoots in one harvest time are presented in Fig. 3. According to increasing dry matter until treatment of 600 mg/kg lead, lead removal was also increased and by decreasing amount of dry matter in high Pb concentration lead removal was also decreased.

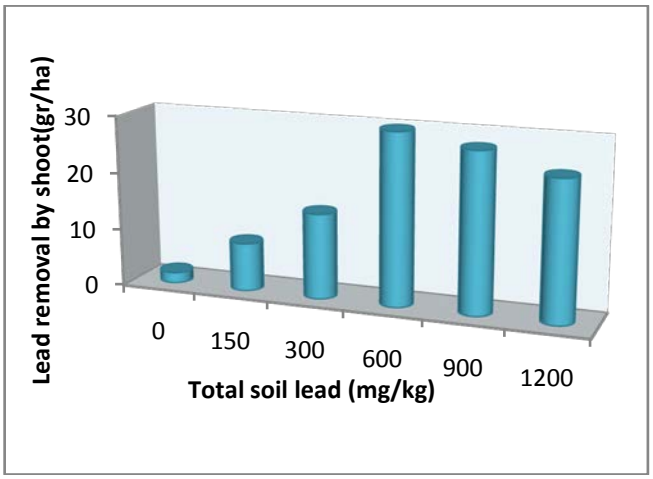


Fig. 3 The relationship between soil Pb concentrations and lead removal by shoots in one harvest

The results obtained from statistical comparison of average accumulative lead in roots and shoots with the Duncan's multiple range test indicate that the highest lead absorption occurred in the treatment with 1200 mg/kg Pb (P = 0.01). But there isn't meaningful difference between amount of lead accumulated in roots of treatments with 600, 900 and 1200 mg/kg Pb.

One of important characteristics of hyperaccumulator plants is high resistance of these plants into high levels of heavy metals. This characteristic with title of resistance index or tolerance index of plant is mean of plant dry matter in highest level of heavy metal per mean of plant dry matter in standard treatment. Plant resistance index for*Chenopodium album* L. was 1.22.

$$\text{Resistance index} = \frac{\text{(mean of dry matter in high level of pollution)}}{\text{(mean of dry matter in standard treatment)}}$$

$$\text{resistance index} = 17691/14485 = 1.22$$

IV.Conclusion

The overall results obtained in this study indicate that by increasing the lead concentration in soil, its accumulation in plant tissues was also increased, furthermore, there was no toxicity for this plant up to 1200 mg/kg soil lead and the highest lead absorption occurred in the treatment with 1200

mg/kg Pb. finally, according to plant resistance index of *Chenopodium album* L. was more than 1. Therefore, concerning its resistant and its high biomass, halophyte *Chenopodium album L*. can be used as a hyperaccumulator plant to remediate lead polluted soils.

References

[1] Asadi Kapourchal, So., Asadi Kapourchal, S., Pazira, E. and Homaee, M. (2009). Assessing radish (*raphanus sativus* L.) potential for phytoremediation of Lead- contaminated soils resulting from air pollution. Soil plant and environment, 55 (5): 202-206.

[2] Chaney R.L., Li Y.M., Brown S.L., Homer F.A., Malik M., Angle J.S., Baker A.J.M., Reeve R.D., Chin M. (2000). Improving metal hyperaccumulator wild plants to develop commercial phytoextraction systems: Approaches and progress. In: Terry N., Banuelos G. (eds): Phytoremediation of Contaminated Soil and Water. Lewis Publishing, Boca Raton, 129–158.

[3] Cunningham, S.D., W.R. Berti and J.W. Huang. (1995). Phytoremediation of contaminated soils. Trends Biotechnol. 13: 393–397.

[4] Finžgar N., Tlustoš P., Leštan D. (2007). Relationship of soil properties to fractionation, bioavailability and mobility of lead and zinc in soil. Plant, Soil and Environment, *53*: 225–238.

[5] Grejtovský A., Markušová K., Nováková L. (2008). Lead uptake by *Matricaria chamomilla* L. Plant, Soil and Environment, *54*: 47–54.

[6] John R., Ahmad P., Gadgil K., Sharma S. (2008). Effect of cadmium and lead on growth, biochemical parameters and uptake in *Lemna polyrrhiza* L. Plant, Soil and Environment, *54*: 262–270.

[7] Kalaji H.M., Loboda T. (2007). Photosystem II of barley seedlings under cadmium and lead stress. Plant, Soil and Environment, *53*: 511–516.

[8] Komárek M., Tlustoš P., Száková J., Chrastný V., Balík J. (2007). The role of Fe- and Mn-oxides during EDTAenhanced phytoextraction of heavy metals. Plant, Soil and Environment, *53*: 216–224.

[9] Kos B., Grčman H., Leštan D. (2003): Phytoextraction of lead, zinc and cadmium from soil by selected plants. Plant, Soil and Environment, *49*: 548–553.

[10] Turan M., Esringü A. (2007). Phytoremediation based on canola (*Brassica napus* L.) and Indian mustard (*Brassica juncea* L.) planted on spiked soil by aliquot amount of Cd, Cu, Pb, and Zn. Plant, Soil and Environment, *53*: 7–15.

[11] United States Environmental Protection Agency (1986). Acid digestion of sediment, sludge and soils. In: Test methods for evaluating solidwastes. EPA SW-846. US Government Printing Office, Washington D.C.

[12] Vysloužilová M., Tlustoš P., Száková J. (2003). Cadmium and zinc phytoextraction potential of seven clones of *Salix* spp. planted on heavy metal contaminated soils. Plant, Soil and Environment, *49*: 542–547.

ISBN: 978-1-61804-224-8

Use of Cluster Analysis method in log's data processing: prediction and rebuilding of lithologic facies

Ameur Zaimeche Ouafi[1], Zeddouri Aziez[1], Kouadria Taib[2], Kechiched Rabah[1], Belaksir Mohammed Salah[1].
1 . Kasdi Merbah Ouargla University, Faculty of Hydrocarbons, Renewable Energy and Earth Sciences and the Universe, Ouargla 30 000 Algeria.
2 . Annaba University, Faculty of Earth Sciences, Annaba 23 000 Algeria.
ouafigeology@gmail.com

***Abstract*— when a core is missing in a drilling hole, geologists hope to deduce it from others cores available in another part of the hole or in a neighboring, in order to define the lithologic facies. This paper presents a Cluster Analysis method uses to predict the no coring facies from other available cores. This method, based on algorithm which is recognition of facies after coding electro-facies using Wireline logging data especially (GR, ROHB., THOR., POTH) and detailed description of cores** [1].

Calculations are made using Matlab and Excel. The prediction and rebuilding results are similar to the real facies in the core. These results showed a significant correlation between prediction, cores facies and corresponding responses of logging peaks (especially Gamma ray). This method has considerable economic benefits permitting a gain of time money and energy compared to coring operation [1]**.**

***Keywords*— Missing Core, Cluster Analysis, Wireline logging, prediction, Matlab, Excel, Economic**

I. Introduction

In order to investigate the subsoil's composition, geologists should realize cores, but the recuperation is not always completed depending on technical feasibility and geological problems encountered during the coring operation, especially in old wells that are partially or completely non-cored. In fact, our work aim is to overcome the lack of geological information; so sensors were taken down in the drilling holes for measuring physical properties of the rocks. We call logs the result of these measures. We applied this process to deduce non-coring interval in the Lower Triassic Clay Sandstone reservoir (TAGI) in Sif Fatima field in the basin of Berkine, (SE Algeria). Usually geologists use the correlation existing between the different available cores and the no coring interval, to deduce the value they need [3], we propose Cluster Analysis method for helping geologists in predict and rebuilding the lithologic facies.

II. Materials and Methods

A. Preparation of core samples

Drilling, cuttings put together by traffic are not always representative For the geologist, the information is incomplete. These cuttings can be from different levels (case of impact) and the ascent of the cuttings is uncertain. In the industry of oil and gas, coring can be defined as "cut and remove a cylindrical sample of rock from the walls of the hole" (Grondin, 2004),
We could identify and discriminate these lithological facies of electro-facies, we give to each facies a code were presented 0-3 to simplify the nomenclature of these facies.
Clay code = 0. Silt, code = 1. Sandstone code = 2,
Sandstone with clay code = 3

B. Wireline Logging

Well logs or Wireline logs are continuous recordings of well depth versus different petrophysical characteristics of the rocks through which the well is drilled. There are many types of well logs, depending upon the characteristics of the rock being measured. [2]. Logging surveys taken after the casing is lowered are usually categorized as cased hole logs Logging surveys taken before the hole is cased are called open hole logs. We interest with data logging open hole especially (Gamma Ray total, Thorium. Potassium and Density) because they give information on lithology**.** [7]

1. Total Gamma Ray

The Gamma Ray log is a measurement of the formation's natural radioactivity; his emission is produced by three radioactive series found in the Earth's crust, Potassium, Uranium, Thorium. [7]

2. spectral Gamma ray

Gamma Rays are bursts of high-energy electromagnetic waves that are emitted spontaneously by some radioactive elements. [7] Nearly all the Gamma Radiation encountered on Earth is emitted by:
-Radioactive potassium Isotope (K40) with half-life 1.3x109.
-Uranium 238 (U238) with half-life of 4.4 x 109.

-Thorium 232 (Th232) with half-life of 1.4 x 1010.

3. Gamma-Gamma (Density)

Measuring the number of gamma rays and their energy levels at a given distance from the source, the electron density (RHOB).of the formation can be predicted. Is known as litho density tool. [7]. In addition to measuring bulk density, it measures the photoelectric factor (Pe) which is an indicator of formation lithology.

C. Cluster Analysis method

Cluster Analysis method is based on the use of logs in the discrimination of facies, facies are recognized electrofacies. An electrofacies therefore corresponds to a set of samples having similar log responses. Determining electrofacies therefore is highly dependent on selected logs from the stratigraphic interval and or geographical area. Cluster Analysis is a method of partitioning data which is a statistical data analysis method. Its purpose is to divide a set of different data "packets" homogeneous [4,5], in that the data in each subset share common characteristics.

It is also necessary to first perform tests to determine the choice of logs to use, determine the number of studies to be conducted based on stratigraphic or geographies necessary In terms of the process, at first, it was necessary to determine for each facies, the differences between the average value of log (VA, VB, VC, VD) and current values at a defined depth (LA, LB, LC, LD). This fact is obtained from a "log deviation" the facies [8].

Then, we calculated the absolute value of this difference and we normalized using the range to each variable. The "log error" takes values between [0, 1], allowing for comparisons.

Then we calculated the error for each facies, which corresponds to the average of the four "log error" and attributed the facies with the minimum of errors for each depth [1].

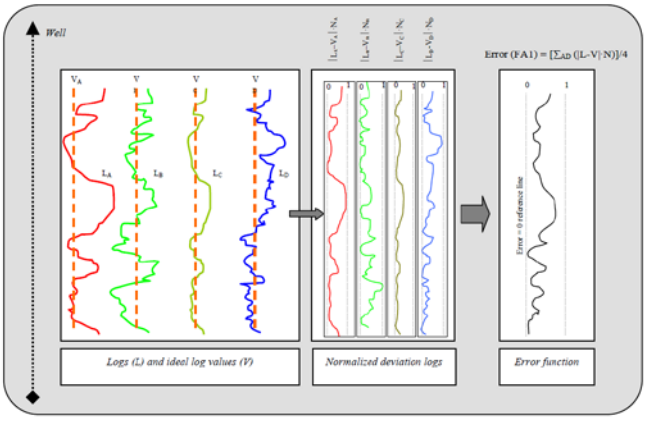


Fig. 1- Diagram summarizes the steps of the Cluster Analysis method.

D. SOFTWARES

1. Matlab

In our work we used the MATLAB software, developed by the American company Matwork. This is very powerful software.

2. EXCEL

This software is a spreadsheet was used primarily for entering and managing data files, it has been used for some calculations,

III. Results and Discussion

First we calculated the average values of each conventional log, were calculated for each facies the average of all values for each logging in all wells.

Table 1. Averages of logs in all cored wells

Facies	***CODE***	**GR (A)**	**RHOB (B)**	**THO (C)**	**POTA (D)**
Clay	0	108,8	2,55	10,86	2,83
Silt	1	91,29	2,57	10,98	2,30
Sandstone	2	64,26	2,43	6,77	1,39
Sandstone and Clay	3	84,98	2,54	7,01	3,29

Than the Maximum, minimum and the range are calculated taking into account all values through all wells maximum and minimum extent of logs in all wells cored values.

Table 1. Maximum, minimum and the range all cored wells

	GR (A)	**RHOB (B)**	**THOR (C)**	**POTA (D)**
MAX	210,29	3,11	23,84	6,10
MIN	13,08	2,12	1,78	0,06
Range	197,21	0,99	22,06	6,04

The most representative peaks are selected as learning samples, these samples determined on the logs are calibrated simultaneously with facies descriptions from core.

- Qualitative visualization of results of prediction

The visualization of the results of the prediction was made with the establishment of logs facies prediction, using the Log discrete control software Petrel (Schlumberger). This allows for a comparison between a prediction and the log of this core. Thus, view logs prediction of non-cored wells and confirm with logging, especially (GR and RHOB). The prediction results of each well in comparison with the core descriptions.

The result of prediction in all the wells was allowed to see the correspondence between a large prediction facies and core facies, there was a decrease in percentage of clays in parallel **i**ncrease in silts. The difference is negligible in the sandstone.

ISBN: 978-1-61804-224-8

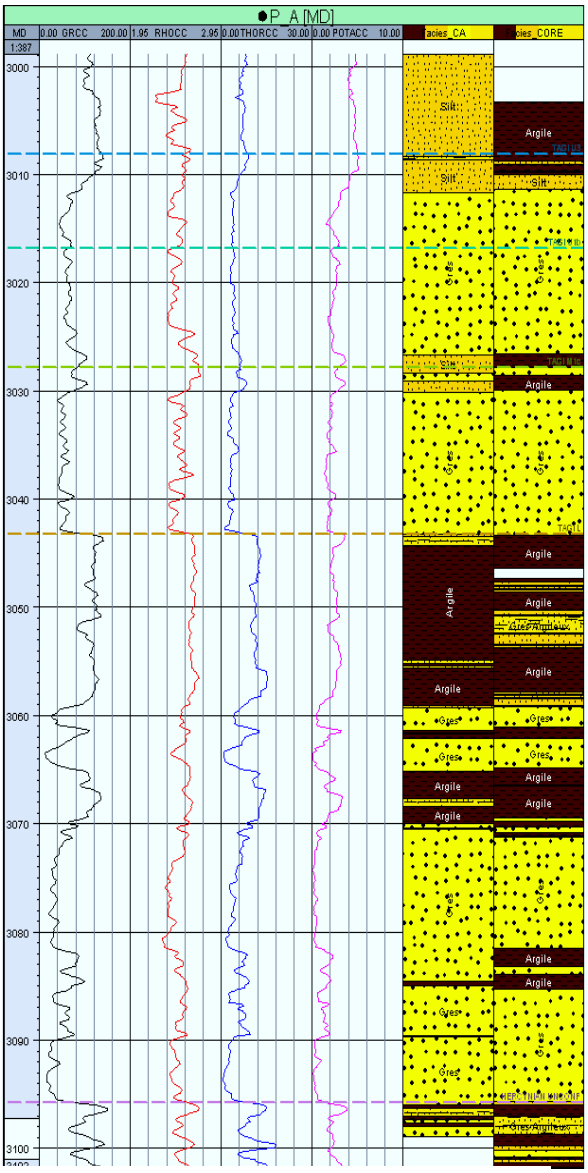


Fig 2. Comparison between results of Prediction and core facies well A

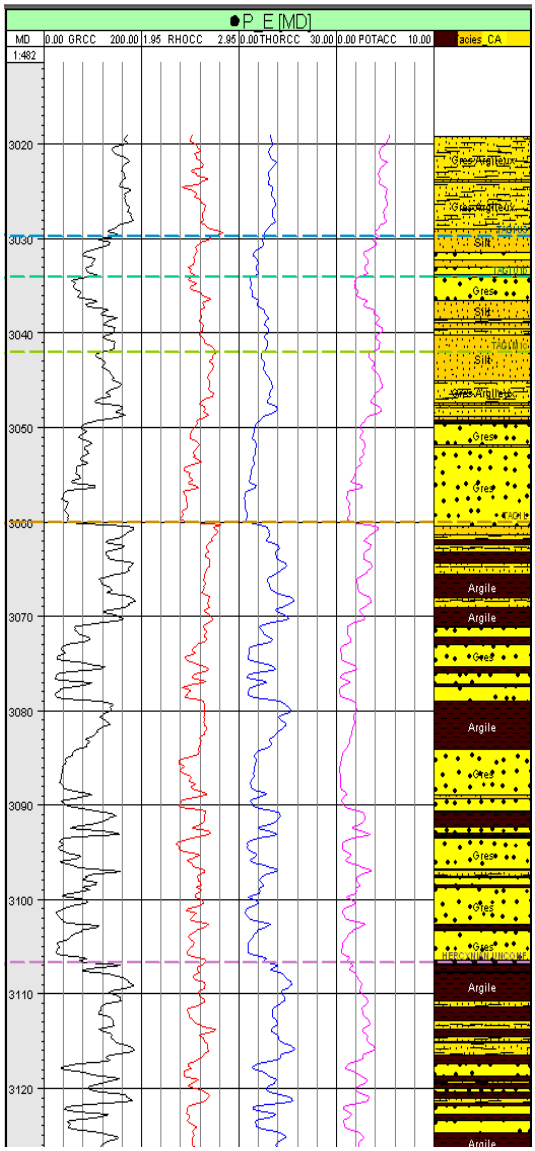


Fig 3.Rebuilding of non-coring well E

We see that well A , a total lack of carrots by substituting facies prediction. There is a perfect response prediction and facies between peaks of logs (gamma ray, density). It was detected very small benches and matching the peaks of logs determining the facies using prediction is generally the same as the facies described in carrot. It was also found the same entered limits benches with the same answers peaks log.

A good description of the core in this interval, facies prediction matches the description core with human eyes.

We take example to radiuses the results of prediction by the well E is a no coring well and we can get the facies corresponding and we look a response with all logs specially Gamma ray

Correspondence between the response peaks logs with facies predictions.

Apart from very thin levels facies consistent with the peak of gamma ray.so we have a virtual core.

ISBN: 978-1-61804-224-8

- Quantitative comparison between prediction and core

The quantitative comparison was made for each cores well. The difference between the percentage of log facies and facies of the core was calculated and this, for each facies. The results were expressed as a histogram table monitoring

Table 3. Complete comparison between the prediction and core

Facies	CODE	Core Facies	Prediction Facies
Clays	0	28%	15%
Siltstone	1	13%	23%
Grainstone	2	55%	56%
Granstone with Clays	3	4%	6%

Prediction gave results very close to the description of carrots in this well. However, the percentage of silts prediction is more detailed description that, while the percentage of clays decreased. This observation is explained by the interference of description between clay and silt. The percentage of sandstone is of benefit increased by 12%.it is explained by the intuition of the Geologist when he describe the core, the siltstone are sometimes difficult to distingue from the clay.

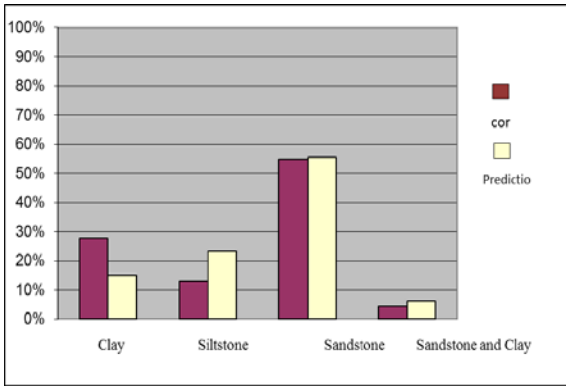


Fig 4. Histogram comparison between the prediction facies core in all coring wells

The result of prediction in all the wells was allowed to see the correspondence between a large facies and facies carrots log (prediction), there was a decrease in percentage of clays in parallel increase in silts. The difference is negligible in the sandstone reservoir facies; it is of the order of one percent (1%).

IV. CONCLUSION

Cluster analysis method was performed for the prediction of non-cored facies and to correct the interference due to difficulties of the macroscopic description. Qualitative and quantitative interpretation were made using a comparison between facies and facies prediction carrot logs and histograms, this comparison has revealed a similarity between the facies prediction and core especially for the sandstone facies, except clay passages merge with silts. Indeed, the prediction has to distinguish between facies are difficult to differentiate macroscopically (silt and clayey sandstone), and with a perfect match peaks logs logging.

It is less expensive compared with the coring operation. And a considerable gain of time. The simulation-facies present interest as to gain time and help in making the decision. This method is like any simulation method has drawbacks among which: The bad description of carrots will influence the calculation of electro-facies and cause errors at the stage of results (prediction).

We doing also another method for prediction using an unsupervised self-organizing neural network to compare with Cluster Analysis how in two method give a good results with minimal error .

REFERENCES

[1] Ameur Zaimeche, O. (2012): Prédiction des facies non carottés par la méthode de Cluster Analysis et contribution à l'étude du réservoir TAGI du Bassin de Berkine SW, Mémoire de fin D'étude, UNIVERSITÉ BADJI MOKHTAR-ANNABA, W.-K. Chen, *Linear Networks and Systems* (Book style). Belmont, CA: Wadsworth, 1993, pp. 123–135.

[2] Chapellier, D. (1998): cours online de géophysique, *Université de Lausanne, Institute français du pétrole*.

[3] Dominique Frayssinet use of neural networks in log's data processing: prediction and rebuilding of lithologic facies

[4] J.C. Bezdek, R. Ehrlich, W. Full, FCM: the Fuzzy c-Means clustering algorithm, Comput. Geosci. 10 (1984) 191–203.

[5] Louis Briqueua, Traitement des diagraphies à l'aide d'un réseau de neurones du type « carte auto-organisatrice » : application à l'étude lithologique de la couche silteuse de Marcoule (Gard, France

[6] Rabaute A. (1999): Obtenir une représentation en continu de la lithologie et de la minéralogie. Exemples d'applications du traitement statistique de données de diagraphie aux structures sédimentaires en régime de convergence de plaques (Log ODP 134, 156 et 160). Thèse de doctorat, Université de Montpellier II. Mémoires géosciences – Montpellier.

[7] SERRA, O. (1985): -Diagraphies Différés base de l'interprétation, Mémoire7 Tome2. Etudes et productions Schlumberger, Montrouge

[8] They, P. P. (1991): Log data acquisition and quality control. Editions Technip, Paris.

Authors Index

ISBN: 978-1-61804-224-8