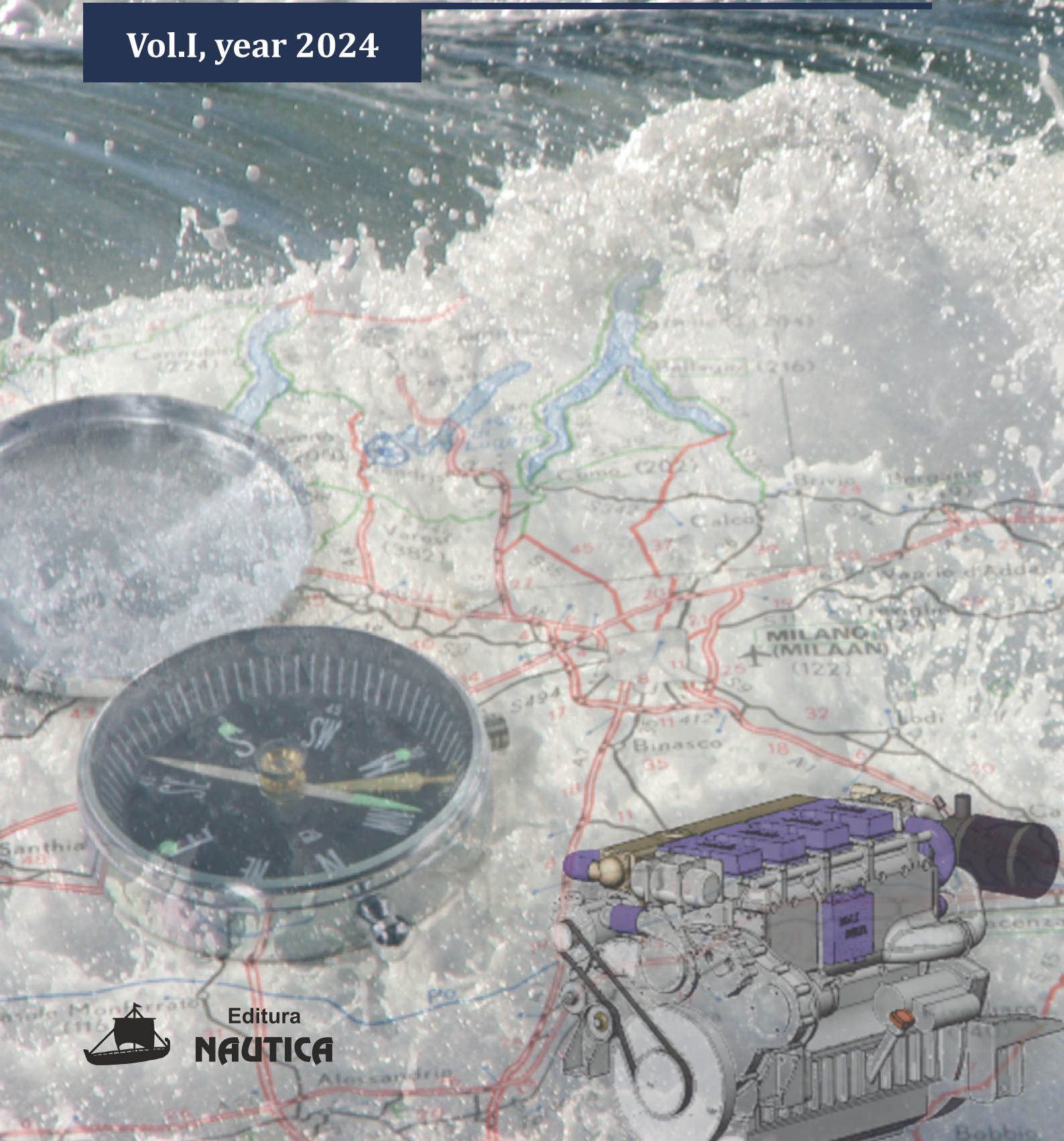


# Journal of Marine Technology and Environment

Vol.I, year 2024



Editura  
**NAUTICA**



**ISSN (Print): 1844-6116**

**ISSN (Online): 2501-8795**



---

**This Journal has been founded in 2008 as a biannual publication of  
Constanta Maritime University/ROMANIA**

## TOPICS

- Marine Science and Engineering
- Marine Environmental Issues
- Marine Renewable Energy and Sustainability
- Maritime Safety
- Marine Chemistry
- Marine Corrosion and Material Science
- Ship Design, Building Technologies
- Ocean Engineering
- Advanced Technologies for MET
- Advances in numerical methods for marine engineering
- Algorithms for multidisciplinary problems in marine engineering
- Other related topics

## EDITOR IN CHIEF

**Prof. PhD. Eng. Mariana PANAITESCU** (Constanta Maritime University, Constanta, Romania)

## VICE EDITOR IN CHIEF

**Assoc. Prof. PhD. Eng. Feiza MEMET** (Constanta Maritime University, Constanta, Romania)

## GUEST EDITOR

**Assistant researcher Jawad LAKZIZ** (University Hassan II of Casablanca , Faculty of Science Ben M'Sik, Morocco)

## EDITORIAL BOARD

Prof. PhD. Angelica M.BAYLON (Maritime Academy of Asia and the Pacific, Mariveles Bataan, PHILIPPINES)

Prof. PhD. Eng. Romeo BOSNEAGU ("Mircea cel Batran" Naval Academy, Constanta, ROMANIA)

Prof. PhD. Eng. Violeta-Vali CIUCUR (Constanta Maritime University, Electromechanical Faculty, Constanta, ROMANIA)

Prof. PhD. Eng. Nicolae BUZBUCHI (Constanta Maritime University, Electromechanical Faculty, Constanta, ROMANIA)

Assoc. Prof. PhD.Eng. Dumitru DELEANU (Constanta Maritime University, Constanta, ROMANIA)

Prof. PhD. Nil GULER (Istanbul Technical University, Maritime Faculty Tuzla, TURKEY)

Assoc. Prof. Mahmoud Reza HAGHDOUSTI (University: Iran Maritime Training Center, Tehran, IRAN)



Prof. PhD. Eng. Gheorghe - Constantin IONESCU (University from Oradea, Faculty of Civil Engineering and Architecture, Department of Civil Engineering, Oradea, ROMANIA)

Assoc. Prof. PhD, MSc/ Dip. Momoko KITADA (WORLD MARITIME UNIVERSITY, Malmö, Sweden)

Assoc. Prof. PhD.Kalin Spasov KALINOV (Nikola Vaptsarov Naval Academy, Varna, Bulgaria)

Prof. PhD. Eng. Gheorghe LAZAROIU (University POLITEHNICA of Bucharest, Faculty of Power Engineering, Department of Energy Production and Use, ROMANIA)

Prof. PhD. Axel LUTTENBERGER (University of Rijeka, Faculty of Maritime Studies Rijeka, CROATIA)

Prof. PhD. Marusya LUBCHEVA (Black Sea Institute Burgas, BULGARIA)

Francesc Xavier MARTINEZ DE OSES (Departament de Ciència i Enginyeria Nàutiques/Universitat Politècnica de Catalunya /SPAIN)

DSc., Professor Irina MAKASHINA (International Education Center of Admiral Ushakov State Maritime University, Novorossiysk, RUSSIA)

Assist. Prof. WALTER K. NADOLNY (Marine Transport and Environmental Management – State University of New York Maritime College, Bronx, NY, USA)

Prof. PhD.Tomasz NEUMANN (Gdynia Maritime University, Faculty of Navigation, POLAND)

Prof. PhD. Sc. Nataliya Danailova NIKOLOVA (University: Nikola Vaptsarov Naval Academy – Varna, BULGARIA)

Prof. PhD. Captain Selcuk NAS (Dokuz Eylul University, TÜRKKEY)

Prof. PhD. Eng. Cornel PANAIT (Constanta Maritime University, Electromechanical Faculty, Constanta, ROMANIA)

Prof. PhD. Eng. Fanel - Viorel PANAITESCU (Constanta Maritime University, Electromechanical Faculty, Constanta, ROMANIA)

Prof. PhD. Eng. Petko Stoyanov PETKOV (University "Prof.Dr. Assen Zlatarov", Burgas, BULGARIA)

Prof. PhD. Stoyanka PETKOVA Georgieva ( University "Prof. Dr. Assen Zlatarov"-Burgas BULGARIA)

Prof. PhD. Hu QINYOU (Shanghai Maritime University, Merchant Marine College, Shanghai, CHINA)

Prof. PhD. Sergii RUDENKO (Odessa National Maritime University/ UKRAINE)

Prof. VAdm Eduardo Ma R SANTOS (Maritime Academy of Asia and the Pacific, Mariveles Bataan, PHILIPPINES)

Prof. PhD. Igor SMIRNOV (Admiral Ushakov Maritime State University, Navigating Faculty, Novorossiysk, RUSSIA)

Prof. PhD Eng., LT (NAVY) Ionuț-Cristian SCURTU (Constanta Mircea cel Batran Naval Academy, MBNA/ ROMANIA)



---

## SCIENTIFIC BOARD

Assoc.Prof. Mykola ADAMCHUK (Odessa National Maritime University, UKRAINA)

Assoc. Prof. PhD. Nicoleta ACOMI (Constanta Maritime University, Constanta, ROMANIA)

Assoc Prof. PhD. Docent Eng. Bohos APRAHAMIAN (Technical University of Varna, BULGARIA)

Senior Lecturer Captain Mahmoud El-Sayed El- BAWAB (Arab Academy for Science Technology and Maritime Transport, Alexandria, EGYPT )

Milen DIMITROV (Black Sea Institute Burgas, BULGARIA)

S.L. Iunusova ELMAZ (Odessa National Maritime University, UKRAINA)

Luis G. EVIDENTE (John B. Lacson Colleges Foundation, PHILIPPINES)

Assoc. Prof. Svitlana GLOVATSKA (Odessa National Maritime University, UKRAINA)

Senior Lecturer Vanyio GRANCIAROV (University "Prof.d-r Assen Zlatarov" Burgas, BULGARIA)

Assoc. Prof. PhD. Radu HANZU (Constanta Maritime University, Constanta, ROMANIA)

Vladimir KANEV (Expert WEB Application Software Sofia, BULGARIA)

Tatiana KOVTUN (Odessa National Maritime University, UKRAINA)

Teresa J.LEO (Universidad Politecnica de Madrid /SPAIN)

Prof. Dr. Valeriu LUNGU Valeriu (Moldova Technical University)

Assoc. Prof. PhD. Lyubcho LYUBCHEV (University 'Prof.d-r Assen Zlatarov" Burgas, BULGARIA)

Prof. PhD. Irena MARKOVSKA (University 'Prof.d-r Assen Zlatarov" Burgas, BULGARIA)

Prof. PhD. Magdalena MITKOVA (University "Prof.d-r Assen Zlatarov" Burgas, BULGARIA)

Assist. Prof. PhD.Sabina NEDKOVA (University "Prof.d-r Assen Zlatarov" Burgas, BULGARIA)

Assoc. Prof. PhD. Alexandra RAICU (Constanta Maritime University, Constanta, ROMANIA)

Assoc. Prof. PhD. Gabriel RAICU (Constanta Maritime University, Constanta, ROMANIA)

Assist.Prof. PhD. Evghenyi RUDENKO (Odessa National Maritime University, UKRAINA)

Assoc. Prof. PhD.Eng. Liviu-Constantin STAN (Constanta Maritime University, Constanta, ROMANIA)

prof. PhD. Habil. Razvan TAMAS (Constanta Maritime University, Constanta, ROMANIA)

Lecturer Capt Emre UCAN (Dokuz Eylul University, TURKEY)



#### **EDITORIAL SECRETARY**

Senior lecturer PhD. Eng. VOICU Ionut (Constanta Maritime University, Constanta ROMANIA)

Assoc. Prof. PhD Catalin Silviu Nutu (Constanta Maritime University & Naval Academy “Mircea cel Batran”, ROMANIA)

#### **COMPUTERIZED EDITING**

IGNAT Irina-Andrea (Constanta Maritime University/ROMANIA)

#### **WEB ADMINISTRATOR**

POPESCU George (Constanta Maritime University/ROMANIA)

#### **JOURNAL ADDRESS**

##### **Journal of Marine Technology and Environment**

Constanta Maritime University, 104, Mircea cel Batran Street, 900663, Constanta, Romania

Tel: +40 241 664 740/ 107

Fax: +40 241 617 260

E-mail: [office@jmte.eu](mailto:office@jmte.eu)

<http://jmte.eu>

**NAUTICA PUBLISHING HOUSE CONSTANTA, ROMANIA**

**CONSTANTA MARITIME UNIVERSITY, 104, MIRCEA CEL BATRAN STREET, 900663, CONSTANTA, ROMANIA**

## CONTENTS

1.	<b>STUDYING THE INFLUENCE OF CELLULOSE TRINITRATE IN THE MODIFICATION OF PROPERTIES OF UNLEADED GASOLINE CO 95 AND VISUALIZING ITS INTERNAL STRUCTURE</b> DORDEA Traian <sup>1</sup> , TUDOR Camil <sup>1</sup> , STĂNIA Lucian <sup>1</sup> <sup>1</sup> Constanta “Ovidius” University, Faculty of Mechanical, Industrial and Maritime Engineering, 132, Mamaia Street, 900721, Constanta, ROMANIA	7
2.	<b>EXPERIMENTAL DETERMINATION OF ADDING CELLULOSE NITRATE TO THE OCTANIC NUMBER OF FUELS</b> DORDEA Traian <sup>1</sup> , TUDOR Camil <sup>1</sup> , STĂNIA Lucian <sup>1</sup> <sup>1</sup> Constanta “Ovidius” University, Faculty of Mechanical, Industrial and Maritime Engineering, 132, Mamaia Street, 900721, Constanta, ROMANIA	11
3.	<b>SMART DEVICE FOR PET RECYCLING</b> PANAITESCU Fanel-Viorel <sup>1</sup> , PANAITESCU Mariana <sup>1</sup> , VOICU Ionut <sup>1</sup> , DUMITRESCU Marius-Valentin <sup>2</sup> , COCARTA Diana-Mariana <sup>2</sup> <sup>1</sup> Constanta Maritime University, Faculty of Naval Electro-Mechanics, 104 Mircea cel Batran Street, 900663, Constanta, ROMANIA <sup>2</sup> Doctoral School of Energy Engineering of National University of Science and Technology POLITEHNICA Bucharest, Blvd. Spl.Independentei, no. 313, sector 6, 060042, Bucharest, ROMANIA	15
4.	<b>YOUNG’S MODULUS OF CALCIUM-ALUMINO-SILICATE GLASSES: INSIGHT FROM MACHINE LEARNING</b> MOUNA Sbai Idrissi <sup>1</sup> , Ahmed El Hamdaoui <sup>1</sup> , Tarik Chafiq <sup>2</sup> , Said Ouaskit <sup>1</sup> <sup>1</sup> Département de physique, Laboratoire de Physique de la Matière Condensée (LPMC), Faculté des Sciences Ben M'Sik, Université Hassan II de Casablanca, BP 7955, Sidi Othman, Casablanca, MAROC <sup>2</sup> Département de géologie, Laboratoire de Physique de la Matière Condensée (LPMC), Faculté des Sciences Ben M'Sik, Université Hassan II de Casablanca, BP 7955, Sidi Othman, Casablanca, MAROC	21
5.	<b>HUNTING FOR GENIUS. WHAT IS BRILLIANCE? CAN A.I. BE BRILLIANT?</b> NUTU Catalin Silviu <sup>1</sup> <sup>1</sup> Constanta Maritime University, Faculty of Naval Electro-Mechanics, 104 Mircea cel Batran Street, 900663, Constanta, ROMANIA	29
6.	<b>EVOLUTIONS IN COMMUNICATION WITH A.I. SYSTEMS OF GENERATIVE PRETRAINED TRANSFORMATIVE TYPE. DEVELOPING A.I. MEDICAL TECHNOLOGIES AND TOOLS BASED ON DATA PREVIOUSLY ACQUIRED BY A.I. E-LEARNING TECHNOLOGY SYSTEMS</b> NUTU Catalin Silviu <sup>1</sup> <sup>1</sup> Constanta Maritime University, Faculty of Naval Electro-Mechanics, 104 Mircea cel Batran Street, 900663, Constanta, ROMANIA	35



7.	<p><b>CROWD PSYCHOLOGY AND PUBLIC ORDER EVENT MANAGEMENT: ANALYSIS OF COLLECTIVE BEHAVIOUR AND EFFECTIVE INTERVENTION STRATEGIES</b></p> <p><b>GENERATING A MESH TO DETERMINE THE BATHYMETRY IN THE HARBOUR</b></p> <p>PETRICĂ Alexandru-Valentin<sup>1</sup></p> <p><sup>1</sup> "Alexandru Ioan Cuza" Police Academy, Bucharest, Police Faculty, Gendarmerie specializations, 1-3 Privighetorilor Alley, 014031 Bucharest, ROMANIA</p> <p>.....</p>	39
8.	<p><b>URBAN DEVELOPMENT AND ENVIRONMENTAL IMPACT IN THE METROPOLITAN AREA OF CONSTANTA</b></p> <p>RAFTU Nicolae<sup>1</sup>, SIRBU Simona Ana<sup>2</sup>, SIRBU Anca<sup>1</sup></p> <p><sup>1</sup> Constanta Maritime University, Faculty of Naval Electro-Mechanics, Environmental Engineering and Protection in Industry, 104 Mircea cel Batran Street, 900663, Constanta, ROMANIA</p> <p><sup>2</sup> National University of Science and Technology POLITEHNICA of Bucharest, 313 Splaiul Independenței, 060042, Bucharest, ROMANIA</p> <p><sup>3</sup> Constanta Maritime University, Faculty of Navigation, 104 Mircea cel Batran Street, 900663, Constanta, ROMANIA</p> <p>.....</p>	43
9.	<p><b>EVALUATION OF DIFFERENT INTERPOLATION METHODS VIA ArcGIS, APPLIED TO SATELLITE DATA OF SEA SURFACE TEMPERATURE SST, CASE OF THE ALBORAN SEA</b></p> <p>RAISSOUNI Ahmed<sup>1</sup>, Abdessalam Ben Harra<sup>1</sup>, Ayoub Belattmania<sup>1</sup>, Samia Elallati<sup>1</sup>, Lhoussaine Ed-daoudy<sup>1</sup>, LAKZIZ Jawad<sup>2*</sup>, Abdelkrim El Arrim<sup>1</sup></p> <p><sup>1</sup> Marine Environment and Natural Hazard Research Team, Faculty of Sciences and Techniques of Tangier, University Abdelmalek Essaâdi, BP 416, 90 000, Tangier – MORROCO</p> <p><sup>2</sup> University Hassan II Casablanca, MOROCCO</p> <p>.....</p>	52
10.	<p><b>EXPERIMENTAL RESEARCH ON THE PRESENCE OF HYDROCARBONS IN THE SOIL OF THE NORTH CONSTANTA ZONE</b></p> <p>VASILICĂ Florentina-Aurelia<sup>1</sup>, SAFTA Carmen-Anca<sup>1</sup>, PANAITESCU Mariana<sup>2</sup>, PANAITESCU Fanel-Viorel<sup>2</sup>, VOICU Ionuț<sup>2</sup></p> <p><sup>1</sup> National University of Science and Technology POLITEHNICA Bucharest, Blvd. Spl.Independentei, no. 313, sector 6, 060042, Bucharest, ROMANIA</p> <p><sup>2</sup> Constanta Maritime University, Faculty of Naval Electromechanics, 104 Mircea cel Batran Street, 900663 Constanta, ROMANIA</p> <p>.....</p>	58
11.	<p><b>DESCRIPTION OF TYPES OF RESEARCH</b></p> <p>VOICU Ionuț<sup>1</sup>, VASILICĂ Florentina-Aurelia<sup>2</sup></p> <p><sup>1</sup> Constanta Maritime University, Faculty of Naval Electro-Mechanics, 104 Mircea cel Batran Street, 900663, Constanta, ROMANIA</p> <p><sup>2</sup> National University of Science and Technology POLITEHNICA Bucharest, Blvd. Spl.Independentei, no. 313, sector 6, 06004, Bucharest, ROMANIA</p> <p>.....</p>	62



## STUDYING THE INFLUENCE OF CELLULOSE TRINITRATE IN THE MODIFICATION OF PROPERTIES OF UNLEADED GASOLINE CO 95 AND VISUALIZING ITS INTERNAL STRUCTURE

DORDEA Traian<sup>1</sup>, TUDOR Camil<sup>1</sup> & STĂNIA Lucian<sup>1</sup>

<sup>1</sup>Constanta “Ovidius” University, Faculty of Mechanical, Industrial and Maritime Engineering, 132, Mamaia Street, 900721, Constanta, Romania, e-mail address:traiandordea@yahoo.com

**Abstract:** Celluloses as a part of biomass can be considered a source of cheap, renewal energy that can be transformed in energy directly through ignition or incorporating it is an usual fuel.

**Key words:** nitrate celluloses, gasoline, microscopy.

### 1. INTRODUCTION

The paperwork has as main objective studying the internal structure of celluloses nitrate and researching its influence in modifying a fuel octane number.

For lab determinations, it has been used the following devices:

- Spectrometer IROX 2000 (fig. 1.) to analyze the chemical ingredients of fuels using Fourier transform on the field 2,7 – 15,4  $\mu$ .
- optical microscope BioROM-T, to get images 4x, 10x,



Figure 1 Analyzer IROX 2000

and 16x;

- microscope with electron scanning CM 120 kV produced by Phillips (Figure 2.).



Figure 2 Microscope CM 120

### 2. MATERIALS AND METHODS

In order to get the fuel mixture cellulose nitrate – premium fuel CO 95,

#### 2.1 Sample 1

- it has been weighed 10g of nitrate cellulose with a nitration degree of approximately 14% that has later on dissolved in 100g. methanol with 95% concentration.

- from the previous mixture, it has been extracted like 5g solution dissolved in 10g. bioethanol;
- this solution was mixed with 100g. CO 95 fuel.
- The mixture was not unitary, after its settling, it was filtered.

## 2.2 Sample 2:

- it has been weighed 10g of nitrate cellulose with a nitration degree of approximately 14% which has later on been dissolved in 100g. methanol with 95% tested fuels;
- from the mixture, it has been taken 5g. solution that was dissolved in 10g. methanol;
- this mixture was blended with 100 ml CO 95 fuel.

Comparing the two samples, there was the following conclusion: the first one made up of CO 95 fuel and 10% bioethanol and the second one contained only CO 95 fuel.

The fuel mixtures were prepared in gravimetric ratios from one reference batch of fuels and alcohols.

## 3. LAB DETERMINATIONS

The samples were analysed with the help of the fuel analyser IROX 2000 and the results are presented in Table 1

Parameter	Gasoline CO 95	Gasoline + 10% bioethanol	Gasoline + nitrate cellulose + bioethanol	Gasoline + nitrate cellulose + methanol
Density [g / cm <sup>3</sup> ]	0,749	0,754	0,758	0,761
Methanol [% vol]	-	-	7,5 % gr.	11,9 % gr.
Ethanol [% vol]	3,6	13,7	4,0	2,8
MTBE [% vol]	-	-	-	-
ETBE [% vol]	5,8	4,9	5,2	5,2
TAME [% vol]	3,1	2,8	2,3	2,6
DIPE [% vol]	-	-	-	-
Benzen [% vol]	0,65	0,56	0,71	0,60
Toluen [% vol]	6,2	4,9	4,9	5,2
m Xilen [% vol]	5,7	4,2	4,6	4,4
o Xilen [% vol]	2,0	1,3	1,4	1,7
p Xilen [% vol]	2,5	2,0	2,2	2,0
Oxygen [% vol]	0	0	0	0
Aromatics [% vol]	36,7	33,8	33,5	33,3
Olefins [% vol]	5,9	1,3	4,5	2,8
Saturates [% vol]	44,5	43,5	43,3	41,8
COM [% vol]	85,1	84,6	84,8	85,2
COR [% vol]	96,1	98,3	95,7	95,9
FBP [°C]	180,4	169,8	193	198,8
P <sub>vap</sub> [KPa]	67,6	74,6	47,5	42,3

Table 1. Relative presentation of main parameters of the tested fuels

## 4. OPTICAL MICROSCOPY

In order to get images, we used an optical microscope BioROM-T, with objectives of x4, x10, x16. The images were recorded with a CCD color video camera

Ikegami ICD-504P model, with a zoom capacity of 3,2x connected to the application Analysis 2.1 through a frame grabber.

The images were expanded in ImageJ, as reference.

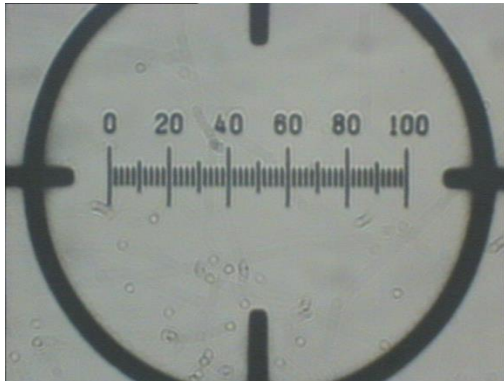


Figure 3 Grid to determine

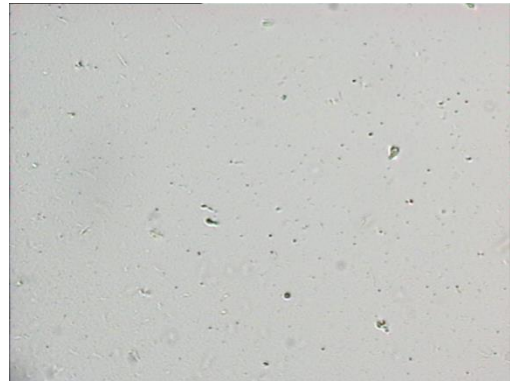


Figure 4 Celluloses trinitrate  
with an increasing factor of 4x

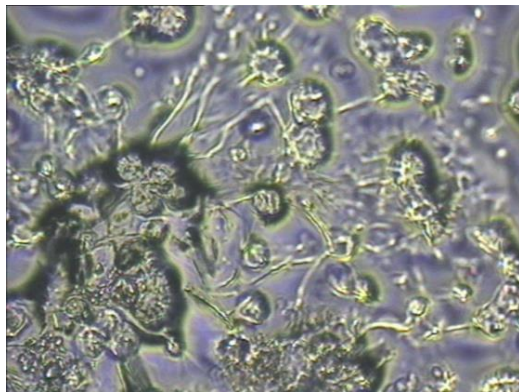


Figure 5 Cellulosis trinitrate,  
with an increasing factor of 10x

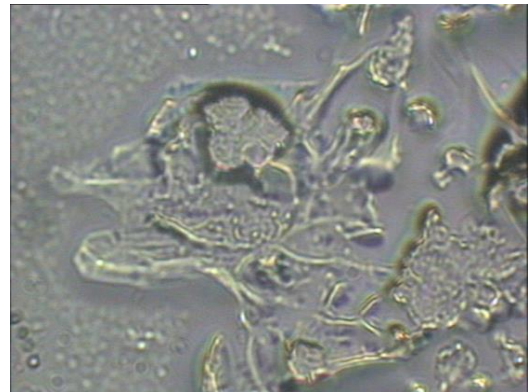


Figure 6 Cellulosis trinitrate  
with an increasing factor of 16x

## 5. ELECTRONIC MICROSCOPY

It has been done with the support of CM 120 which is a microscope, capable to scan by releasing electron beam with a maximum of 120 kV produced by Phillips company (Figure 2).

- *Preparing samples for analyzing:*

- It is released in absolute alcohol
- Ultrasounding for 30 minutes
- A tiny drop is put on the grid covered in formvar
- It is waited the evaporation of alcohol or it is put in vacuum for 1 hour.

Optionally (it is indicated several times) the sample can be cleaned with the help of a plasma cleaner.

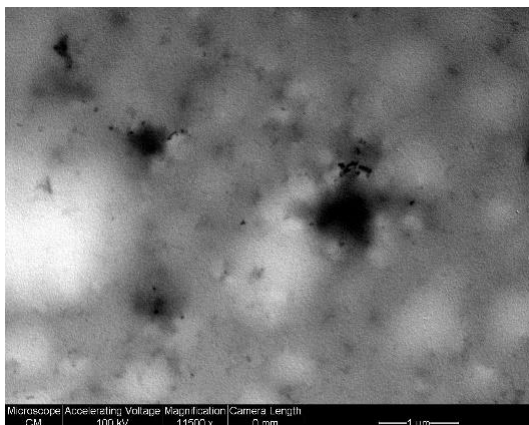


Figure 7 Internal structure of trinitrate cellulose  
with an increasing factor of 11.500X

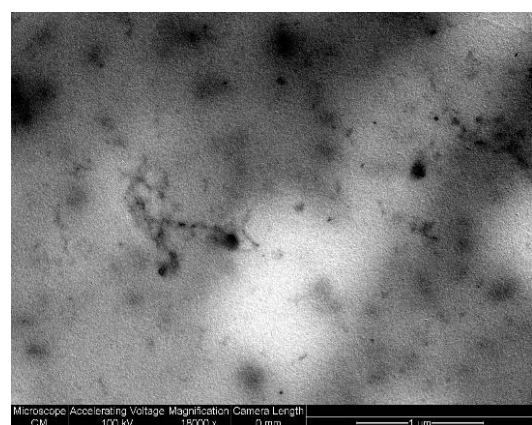


Figure 8 Cellulosis fibers, dimension between 5-6  
nm. factor of increasing 11.500X

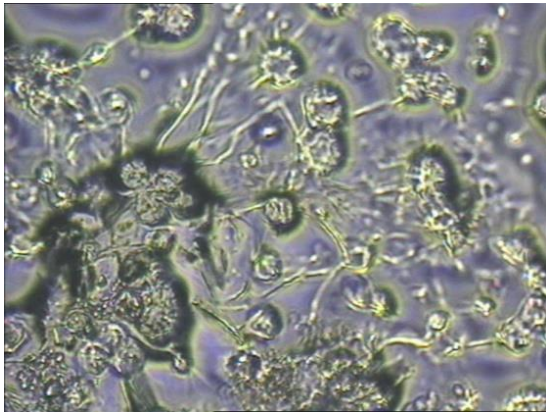


Figure 9 Molecule of trinitrate cellulose, with an increasing factor of 87.000X

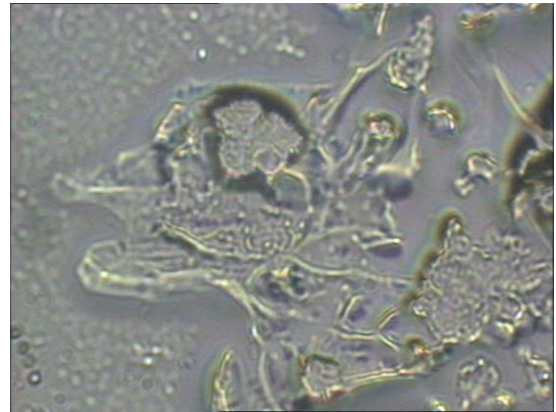


Figure10 Molecule of trinitrate cellulose with an increasing factor of 180.000X

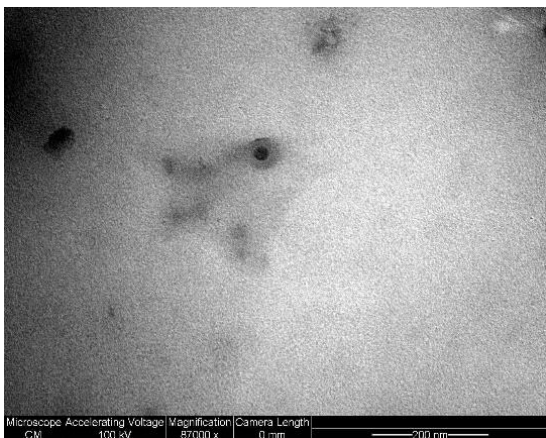


Figure 11 Carbonate atom with an increasing factor of 87.000X

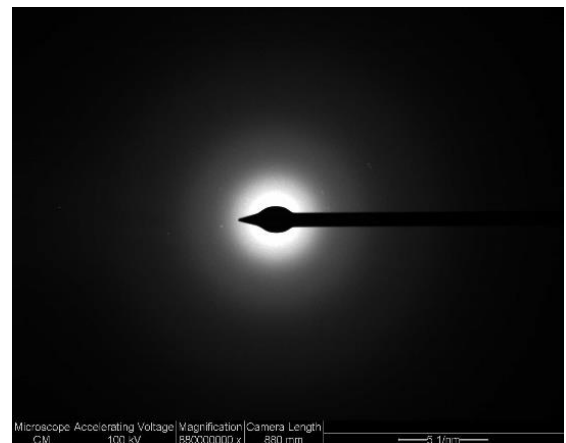


Figure12. Atomic levels of celluloses trinitrate with an increasing factor of 880.000.000X

## 6. CONCLUSIONS

Testing the samples previously presented allowed the conclusion that the trinitrate cellulose can be used as additive to improve energetic properties of fuels although in the data base of analyzer IROX 2000 there are no references for celluloses and nitrate fuels.

## 7. REFERENCES

[1] Dordea, T., 2016, "*Cercetări privind posibilitățile de tratare a unor explozibili pentru obținerea de combustibili destinați motoarelor cu ardere internă*", PhD thesis, Constanța, ROMANIA.

[2] Prodan, G., 2014, "*Metode de estimare și interpretare a imaginilor*" Editura Ovidius University Press, Constanta, ROMANIA.

[3] Dumitrascu, D., Chiru, A., 2007, "*Experimental Researches Regarding the Usage of Alternative Fuels for Vehicles Engines*", BULLETIN OF THE

It is interesting that it is used an explosive for increasing the octane number of a fuel, defined as the resistance at self-ignition, resistance to detonation.

The usefulness of celluloses as trinitrate to modify the octane number of fuels for spark ignition engines represents something new and it takes studying influences and its impact in the engines operation.

TRANSILVANIA University of Brasov, vol. 14 (49), Brasov, ROMANIA.

[4] Lin, W. Y., et al., 2010, "*Effect of Ethanol-Gasoline Blends on Small Engine Generator Energy Efficiency and Exhaust Emission*", Journal of the Air & Waste Management Association, vol. 60, pp. 142-148.

[5] Nakama, K., Kusaka, J., Daisho, Y., 2009, "*Effect of Ethanol on Knock in Spark Ignition Gasoline Engines*", SAE, pp. 5-6.

## EXPERIMENTAL DETERMINATION OF ADDING CELLULOSE NITRATE TO THE OCTANIC NUMBER OF FUELS

DORDEA Traian<sup>1</sup>, TUDOR Camil<sup>1</sup> & STĂNIA Lucian<sup>1</sup>

<sup>1</sup>Constanta "Ovidius" University, Faculty of Mechanical, Industrial and Maritime Engineering, 132, Mamaia Street, 900721, Constanta, Romania, e-mail address:traiandordea@yahoo.com

**Abstract:** The paperwork has as purpose improvement of anti-explosive properties of liquid fuels for spark ignition engines through nitrate addition and quantitative determination of the octane number resulting from the CFR ASTM Waukesha engine support.

**Key words:** nitrate cellulose, fuel, octane number.

### 1. MATERIALS AND REACTIVE/ REAGENTS USED TO DETERMINE OCTANE NUMBER

The materials and reactive/reagents which are necessary to determine octane number are:

- burette 300 mL with a maximum volumetric tolerance of  $\pm 0,2\%$  and standardized ( $20\pm 5^\circ\text{C}$ );
- standardized barometer;
- dosing cylinders with different standardized capacities (50mL, 250mL, 500mL and 1000m L);
- 1 L glass vials to prepare primary fuels;
- N-heptane, a minimum purity of 99,75% volume, with max. 0,1% volume isooctane and not more than 0,5 mg/L plumb;
- isooctane (2,2,4 trimetil pentane), purity a minimum 99,75% volume, with a maximum of 0,1% heptane normal volume and no more than de 0,5 mg/L lead;
- fuel with cu COR 98 additive;
- bioethanol with purity of minimum 99.97 %;
- methanol with purity of minimum 99.97 %;
- cellulose trinitrate.

### 2. METHODOLOGY OF DETERMINING OCTANE NUMBER

The testing sample is kept in 1 L laboratory flask, at a temperature of 0 - 6 °C, protected from direct and strong light.

The functioning of ASTM-CFR F1/F2 engine is checked and ensured by controlling and adjusting some parameters before engine start in accordance to the mode and values within the engine operation book:

- level of oil within the crankcase;
- level of cooling liquid within condenser;
- adjusting compression ratio;
- adjusting admission and evacuation valve clearance;

- opening valves on the engine water circuit.

It is recorded the barometric pressure from the location, needed to adjust micrometer for ensuring the corresponding compression pressure, according to Table A4 from ASTM D 2699 [1], [2].

The engine electric supply is switched on from the main button.

The oil crankcase is heated at  $57\pm 8^\circ\text{C}$  and the engine cooling circuit is open.

Tank 4 is loaded with warming up fuels and a little compression ratio of approximate 5,5 is ensured.

The electric engine is started, connected to the fly-wheel of the piston, for a constant speed (600 rpm).

The push button to ignite the spark with an advance angle of  $13^\circ$ .

The air is getting warmed up (IAT for RON = Table A.6.4) and the pressure of the oil is checked to be between 172...207 kPa or 25...30 psi;

The warming up of the fuel mixture is started (MIXT) ensuring a temperature of minimum  $141^\circ\text{C}$  ( $285^\circ\text{F}$ ).

Tank 4 is opened so that the fuel enters the engine and the engine is functioning between 15 and 30 min. with the warming fuel.

Two standards are prepared (mixtures of primary reference fuels: isooctane and regular heptane, a volumetric mixture at burette, with different octane numbers according to ASTM D 2699 and which involves the octane number of the test sample.

The engine is warming up for 15-30 minute, to reach the proper functioning parameters.

The following are loaded:

- tank 1 with inferior COR standard;
- tank 2 with toluene (checkup fuel)
- tank 3 with premium COR/COM standard

The engine containing check-up fuel is tested. If COR is within the parameters from Table 2, then the actual determination follows and if not, the procedure

„FIT for USE” sets off, adjusting air temperature for IAT.

The following are loaded:

- tank 1 with inferior COR standard;
- tank 2 with toluene (checkup fuel);
- tank 3 with premium COR/COM standard;

Then, it comes the actual attempt:

- The compression degree is adjusted, by correcting the cylinder height according to the air pressure, Tables A.4.9. from ASTM 2699 for the sample [2].
- The liquid level in all 3 tanks of the carburate so that it will be a maximum explosion [2];

- While the engine is in use, on the inferior COR standard and also upon the superior/premium, the adjustment is done so that the explosion parameters should be between 20 and 80 units on knock-meter scale;
- The level of liquids within the tanks is adjusted so that there will be maximum explosions;
- There will be 2 readings of the explosion for both standards and 3 readings for the testing sample, writing down the corresponding divisions from the knock meter.

The reading order: the order in which the readings are repeated (for the testing sample and respectively the two beginning standards) is the one from Figure 1 from ASTM D 2699.

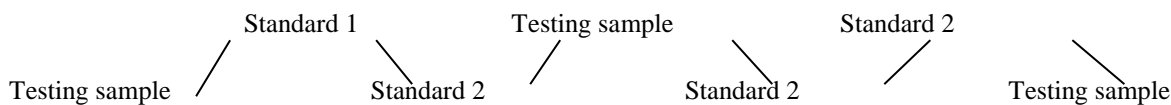


Figure 1 The reading order -ASTM D 2699

The difference between the three readings on the Detonometer for the testing sample, as well as the two readings for each standard must not be higher than 0,3 ON units.

If these conditions are not achieved, there will be another readings, restarting the procedure from „ *Order of reading*” in this sequence.

Differences admitted between the COR of the sampling fuel and COR of the standard mixtures used to register the sample, depending on the supposed octane number of the sampling fuel and must be in the limits from Table 5 ASTM D 2699 [2].

On the field

COR 80-90 ... .. 2 ON units

COR 90-100 ... .. 1 ON unit.

Across the trial of the respective fuel, the engine is continuously supervised to be aware of any malfunctions like speed of rotations, spark ignition advance, according to some rules from the equipment file of trials /measurements no 56.

In case of lack of water or energy supply, fuel supply is also stopped and as a result the octane number engine.

There will be one single trial (testing sample) but with 3 readings of the explosion intensity for the same sample testing, although there will be triple results for the measured particularity, in conditions of repeatability.

#### 4. CALCULATION AND EXPRESSING RESULTS

The average grade of the readings on the knock meter is calculated separately, on testing sample and respectively for each of the two standard mixtures.

Calculating the octane number of the testing sample is the average calculated for the corresponding readings on the knock meter.

$$ON_S = ON_{LRF} + \frac{KI_{LRF} - KI_S}{KI_{LRF} - KI_S} = ON_{HRF} - ON_{LRF} \quad (1)$$

$ON_{LRF}$  = octane number of inferior isooctane and n-heptane mixture;

$ON_{HRF}$  = octane number of superior isooctane and n-heptane mixture;

$KI_{LRF}$  = intensity of the explosive mixture of inferior isooctane and n-heptane;

$KI_S$  = intensity of the fuel under research;

$KI_{HRF}$  = intensity of explosive mixture of superior isooctane and n-heptane;

Results are expressed in octane number units, the ratio being calculated according to the octane number and will be rounded to the closest even number.

It was selected from the guide table A6.3 from ASTM D 2699 [2] for CO/R and we found at the intersection of both lines (horizontal and vertical) a value DIAL INDICATOR is 0,504" where we will note that 29,89 inches, the compensation value is 0,000.

In this table it is written the intake air temperature IAT and we found out that we must have an IAT of 51,7.°C(°F). At the value from the guide table, we will compensate this value using Table A6.4 from ASTM D 2699 [2] 0,504" - 0,000 = 0,504. So the value of cylinder height at the pressure in location is 0,504". After the engine reached the optimum functioning parameters, it is the IAT temperature, the compression ratio is decreased at the value of 0,504", the value of the signal amplitude is adjusted but also the SPREAD value, which exists with signal between the standards with the table from Figure A 4.6 from ASTM D 2699 [2] (intensity of the explosion KI spread/octane number), is written in the





mentioned order at page 46 from this portfolio, after calibrating the level of fuel in every bowl of the carburettor at a maximum explosion rate and we have; The KI intensity of the fuel to determine is 50 (an average between the three readings), the average of the

two readings of KI of inferior level 89 is 54 and the average of the two readings of the superior KI standard is 35. This information is introduced within the calculation algorithm for the standard fuel [3, 4, 5]:

$$CO/R = 89 + \frac{54-50}{54-35}(91 - 89) = 89 + 0,42 = 89,42 \quad CO/R \quad (2)$$

Which mentions that as far as the fuels are concerned, those between CO/R 87,1-91,5 the engine for trial is ready to be used. This way, we can determine the values of octane numbers through RESEARCH method but also through the MOTOR method of all fuels that should be measured.

The properties of the market fuels depend a lot of the characteristics of the oil they originate in, the distillation procedure, different recipe containing specific ingredients and additives dosages.

The anti-explosive features of the fuels depend on their chemical composition. For research, we worked with different types of fuels with different anti explosive features like:

fuel CO/R = 90,1 and CO/M = 80,6; fuel CO/R = 93.0 and CO/M = 83.0; the unleaded gasoline CO/R = 95,4 and CO/M = 85,2. Using bio-ethanol and MBTE as additives for increasing anti explosive features of fuels,

as an experimental base, there were linear results in increasing octane numbers CO/R as well as CO/M. Increasing anti explosive features was higher for non-additive fuels, not because of higher concentration used for additive but mostly due to their chemical composition. Thus, introducing high quantities of additives, the ratio between CO/R and CO/M increased because of decreasing sensitivity of fuels.

Sensitivity of a fuel refers when anti explosive features properties decrease when the engines' functioning conditions turn more harsh, at higher rotations/revolutions. CO/R represents a milder functioning way of the engines while CO/M represents a more competitive way of functioning in harsher conditions, more exactly the engine CFR ASTM (F1) uses a functioning rotation/revolution of 600 rpm for CO/R, and 900 rpm for CO/M.(F2).

## 5. DETERMINING THE CONTRIBUTION OF CELLULOSE NITRATE TO THE MODIFICATION OF THE OCTANE NUMBER OF NAPHTHA FUEL OF 71 CO/R

To determine the importance of celluloses nitrate for modifying octane number of 71 CO/R naphtha fuel, we used a mixture made up of:

To achieve the previous mixture:

- 215 ml. 71 CO/R naphtha fuel;
- 300ml. methanol with a 99,7 % concentration;
- 50 ml. solution, a mixture made up of methanol with 99,7 % concentration and 4,7 cellulosis nitrate,

To calculate the theoretical octane number of the mixture, it will not be taken into consideration the cellulose nitrate introduced within the mixture.

The theoretical octane number of the mixture will be:

$$CO_a = \frac{V \cdot CO_m + (100-V) \cdot CO_N}{100} = \frac{350 \cdot 114 + 215 \cdot 71}{565} = 97,63 \quad (3)$$

where:

CO<sub>a</sub> – octane number of the mixture;

V – volume in percentages of the additive hydrocarbon;

CO<sub>N</sub> – octane number of the naphtha fuel; CO<sub>h</sub> - octane number of the methanol.

Determining the octane number resulting from introducing the 4,7g celluloses nitrate within the fuel, as done in accordance to the methodology to determine octane number depicted previously [6].



This determination was done by comparing the mixture of the fuel realized with a standard fuel with an octane number known on a special engine mounting, being composed out of a lab spark ignition engine, single cylinder, four-stroke engine with a ratio of variable compression (Cooperative Research Fuel CFR Waukesha, U.S.A. fig.1.), in normal conditions, settled by American Society for Testing and Materials) ASTM. As a result, it was stated that the mixture has an octane number of 102,5 CO/R

Figure 1 CFR Waukesha F1 / F2 Engine [3]

## 6. REFERENCES

[ 1 ] Dordea, T, 2016, *Research on the possibilities of treating some explosives to obtain fuels intended for internal combustion engines (Cercetări privind posibilitățile de tratare a unor explozibili pentru obținerea de combustibili destinați motoarelor cu ardere internă)*, PhD thesis, Constanța, Romania.

[2] \*\*\* *Standard method of testing for determination of octane ratings research and motor fuels for spark-ignition engines ASTM D 2699 - 12 and ASTM D 2700 - 12*

[3] Bobescu Ghe, s.a., 1998, *Engines for vehicles and tractors (Motoare pentru autovehicule si tractoare)*, Technical publish House, Bucharest, Romania.

[4] Derek, Bradley, 2006, *Engine autoignition: The relationship between octane numbers and autoignition delay time*, Science Direct.

[5] Manea, L., Manea, A., Buzbuchi, N., Dragalina, A., 2000, *Thermal Engines for port transportation*, Matrix-Rom, vol I,II ISBN 973-685-704-2 Bucharest, Romania.

[6] Roberto, Santana., Phuong, Doa., Malee, Santikunapoma., Walter, Alvarez., 2005, *Octane number prediction for gasoline blends*, Science Direct.



## SMART DEVICE FOR PET RECYCLING

PANAITESCU Fanel-Viorel<sup>1</sup>, PANAITESCU Mariana<sup>1</sup>, VOICU Ionut<sup>1</sup> & DUMITRESCU Marius-Valentin<sup>2</sup>, COCARTA Diana-Mariana<sup>2</sup>

<sup>1</sup>Constanta Maritime University, Faculty of Naval Electro-Mechanics, 104 Mircea cel Batran Street, 900663, Constanta, Romania, email: viopanaiteescu@yahoo.ro, panaitescumariana1@gmail.com, ionut.voicu@cmu-edu.eu

<sup>2</sup>Doctoral School of Energy Engineering of National University of Science and Technology POLITEHNICA Bucharest, Blvd. Spl.Independentei, no. 313, sector 6, 060042, Bucharest, ROMANIA, email: marius\_valentin30@yahoo.com

**Abstract** : PET (polyethylene terephthalate) is a common plastic substance used to make water bottles, carbonated drinks, juices and others. PET is durable and easy to transport, but can be difficult to degrade in nature. If not recycled, PET can remain in the environment for hundreds of years, polluting the sea and other environmental areas.

The work presents the creation of a smart device, which can easily, with low costs, be transformed in laboratory conditions, respecting the steps of the industrial technological process, of polyethylene terephthalate (PET) into recycled PET. The final goal is to research the mechanical characteristics of recycled PET. The method used is *Computer Assisted Thermoplastic Extrusion*, the main parameters of the entire technological process being permanently monitored. The results of mechanical and thermal tests were demonstrated that recycled PET can be transformed into filament for 3D printing of finished products that have properties similar to those obtained industrially.

**Key words** : Device, polyethylene terephthalate (PET), parameter, extrusion, mechanical characteristics.

### 1. INTRODUCTION

In the world of plastics there are different types of synthetic materials. One of them is PET (polyethylene terephthalate). It belongs to the polyester group and is a type of plastic raw material derived from petroleum. Many people do not know what PET is. It was discovered by British scientists Winfield and Dickson in 1941, who patented it as a fibre-making polymer. It is very useful today. [1]. It is a semi-crystalline thermoplastic material created by the condensation of terephthalic acid and ethylene glycol. This material can be found like: semi-crystalline PET, amorphous PET and glycol modified PET with higher impact resistance. PET is durable and easy to transport, but can be difficult to degrade in nature. If not recycled, PET can remain in the environment for hundreds of years, polluting the sea and other environmental areas [1].

Recycling PET reduces the amount of waste that ends up in the environment and saves natural resources by reducing the need to extract new raw materials to make new bottles. In addition, PET recycling can reduce greenhouse gas emissions and the energy required to manufacture new plastic products. PET is a difficult material to extrude due to hygroscopic tendencies and for this reason, PET should be extruded with a moisture. During 4 hours the drying temperatures are in the range 120 ...150<sup>0</sup> C. After drying, the PET needs to be

processed immediately because it can result in many degradations in the structure of the material. PET material must be dried in air for 25 hours at about 130<sup>0</sup> C, when it can have a mass loss after only a few minutes during a degradation test in air at 270...280<sup>0</sup> C. For a vacuum-dried material with the same parameters, no loss of material is recorded [2]-[7].

Temperature and pressure play an important role in the processes of obtaining PET filament because thermal and thermo-oxidative processes of degradation of the material occur [10]-[12].

There are several methods to recycle PET bottles, including washing and sorting the bottles, which are then turned into recycled materials for use in making new products such as clothes, car mats or even other bottles [4], [6]. This process can save energy and reduce greenhouse gas emissions.

PET has the following characteristics: processable by blowing, injection, extrusion; excellent mechanical properties; bio-orientable; cost / performance; first place in recycling.

Like all materials, there are some disadvantages to PET. Drying is one of its main disadvantages. All polyester must be dried to avoid loss of properties. The moisture content of the polymer upon entering the process must be a maximum of 0.005% [2].

In this paper, will be presented an smart automatic device, which can used to transformed into PET flakes and finally, into products.

## 2. GENERAL INFORMATION ABOUT PRODUCTION LINE FROM OTHER DEVICES FOR PET RECYCLING

### 2.1 The disadvantages of PET recycling:

Equipment cost is a disadvantage for PET, as is temperature [2]. Bio-oriented injection moulding equipment is a good reward based on mass production. In blow moulding and extrusion, conventional PVC equipment can be used, which has more versatility to produce different sizes and shapes.

When the temperature exceeds 70 degrees, polyester cannot maintain good performance. Improvements were made by modifying the equipment to allow hot filling. Crystalline (opaque) PET has good temperature resistance, up to 230 °C [2]. Not recommended for permanent outdoor use.

### 2.2 The benefits of PET recycling:

We have unique properties, good availability and excellent recycling. Among its good properties we have clarity, gloss, transparency, gas or flavour barrier properties, impact strength, thermoform ability, easy to print with ink, allowing microwave cooking [2], [3].

### 2.3 Other solutions for automatic devices for PET recycling line:

Recycled PET may be used in a wide variety of final applications. As the quality of the collected PET bottles varies significantly from country to country, and even within the same country and as their conditions can be very bad, it is necessary to be continuously informed on the technologies and technical solutions of PET recycling line, in order to correctly process the most difficult and contaminated materials and reach the best final quality.[4]. Exist different plants for PET recycling, like: 500kg/h PET Cleaning and Recycling Production Line (China [4], 3000kg/h PET Bottle Recycling Line(India)[4], 5000kg/h PET Bottle Recycling Plant (UAE customer) [4], 6000kg/h PET Bottle Recycling Plant (America customer)[4], etc. All of these have: PET bottle washing and recycling machine, line for mixed soft and hard material washing and recycling machine, film washing and recycling machine, PET sheet extrusion line (Figure 1), (Table 1) [5], PET strap production line (Figure 2) [6], PET fibre production line (Figure 3)[7]. The flow of PET fibre production line is presented in Figure 4 [7].



Figure 1 Dryer-free PET Double Venting Sheet Line [5]

where exist a free of crystallization drying system with with the simple operation, low power cost, low production's costs.

Table 1. Technical parameters for PET sheet extrusion line, [5]

Model	PET single layer	PET multilayer
Extruder Specification, diameter $\Phi$ [mm]	120/33	120/33, 65/33
Products Width, [mm]	500-1500	500-1200
Products Thickness, [mm]	0.20-1.5	0.20-1.5
Capacity(Max., kg/h)	450	500
Main Motor Power, [kW]	132	132/45
Design Production Speed, [m/min]	20	25



Figure 2 PET strap production line [6]



Figure 3 PET fiber production line [7]

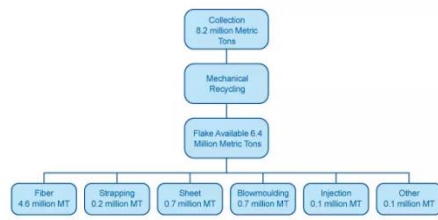


Figure 4 Flow chart of PET fibre production line [7]

Another PET recycling machines [8] has a complete line according to different customers needs (Figure 5).

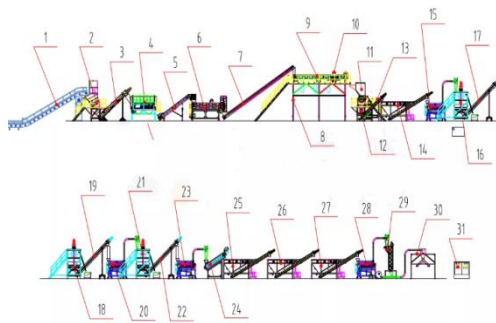


Figure 5 Main flow chart of complete PET recycling line [8]

where: 1-bale breaker; 2-elevated belt conveyor; 3-trommel; 4-belt conveyor; 5-mechanical label remover; 6- belt conveyor; 7-metal detector; 8-manual sorting table; 9- belt conveyor;10-crusher/granulator; 11-screw feeder; 12-float washing tank; 13- screw feeder; 14-hot washer; 15- screw feeder;16-horizontal friction water; 17-floating tanks; 18- screw feeder; 19-dewatering machine; 20-hot air pipeline drying system; 21-loosened label separator; 22-silo. Technical parameters of this line are only for reference (Table 2)[8]:

Table 2. Technical parameters for PET sheet extrusion line, [5]

Production capacity [kg/h]	Total installation power [kW]	Water consumption [m <sup>3</sup> /h]	Line size [mm]
300-500	70-125	3-5	45x5x5
1000-1500	360	5-8	75x5x5
2000	450	8-10	106x6x6
3000	640	10-12	132x7x7

The final products humidity is below 1%, impurities 100ppm, the whole line capacity is about 300 ..2000

## 4. RESULTS AND DISCUSSIONS

### 4.1 Industrial PET film production

kg/h, flakes size 6 ..14 mm, transparency is 90%.

## 3. MATERIAL AND METHODS

The technologies used to identify and sort the waste are essential to obtain the best quality PET flakes, which later become raw material in other production processes.

### 3.1. Transforming PET into tape

The steps of a PET tape production technology are; sorting, milling, washing and packing [9].

**Sorting:** The first step is breaking the bales and separating the bottles according to colour and type of material. By using a rotary sieve and ballistic system, impurities such as dust or sand particles are removed mechanically, and polymers other than PET, such as PE films, cardboard or papers are removed manually. Metal scraps found in the bales are automatically removed using a magnetic separator. Also, aluminium waste (beer cans, cans) is eliminated with the help of an automatic sorting system. In the last phase, the PET bottles are optically sorted by colour, after which they are transported and distributed to the feed mouths of the grinding mills.

**Milling:** PET plastic is ground into PET granules of 8 to 12 millimetres.

**Washing:** PET tapes are washed and separated using high precision equipment.

**Packaging:** PET tapes are packed in special big-bag covers, approx. 1 ton. The contents of each bag are tested in quality laboratories before being sent to the final processors.

### 3.2. Transformation of recycled PET into products

The phases of that technology are [10], [11]:

- **PET tape:** made from 100% recycled tapes, PET tape is a binding product of excellent strength and durability, used in the wood, metallurgical, textile or construction industries;

- **from PET filament to granules:** PET granules are obtained from 100% recycled PET and become raw material for the production of food and non-food packaging;

- **the application of ecological recycling technologies:** obtaining the filament for the 3D printer from PET tape.

On the industrial technological line, the aspects of reliability and intelligent operational control can be observed [9]-[11]: technology without pre-drying; efficient vacuum system with minor losses; optimized equipment design; accessible and efficient control on

technological steps (Figure 6) [11].



Figure 6 PET sheet line control system [11]

In Fig.6 the maximum output production is 821 kg/h (power or motor of extruder is 160 kW, diameter of screw is 93 mm), minimum output production is 686.8 kg/h (power or motor of extruder is 110 kW, diameter of screw is 71.4 mm)[11]. Can work on different rotations (maximum 306.2 rpm; minimum 42.7 rpm)[11].

The steps of operational flux are [11]: loading; transit silo; loss-in-weight feeding; twin screw compounding; cooling stack and edge cutting; thickness testing; corona treatment; silicon/anti-static coating and drying; protection film coating; haul-off; automatic wintering with accumulator.

PET can be extruded with single or twin-screw extruders. In the process with single screw extruder the screw speed is better controlled than in process with twin-screw extruders.

#### 4.2 The automatic device for PET film

The study presents an automatic device, which was created in laboratory conditions. The purpose of creating this device in the laboratory was to give students the opportunity to train some practical skills, following the operational flow on a different scale, more economical in terms of costs.

The device consists of (Figure 7, Figure 8):

- 1-logic board based on a microprocessor Atmega 328;
- 2,3- two stepper motors Nema 17 Advance 1 and Advance 2;
- 4-an extruder with temperature sensor;
- 5- fan,;
- 6- LCD display 2004 Blue compatible I2C;
- 7-buttons control;
- 8- power supply 12V / 6A.

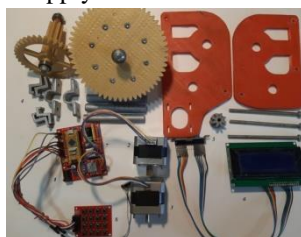


Figure 7 The components of device

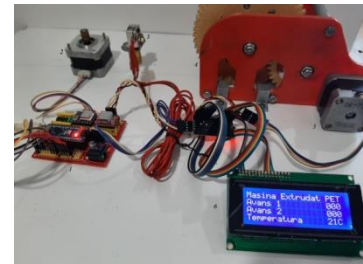


Figure 8 PET film assembly

The working mode of this device is:

- the first stepper motor, called *Advance 1*, ensures a constant speed of the material (PET) at the entrance to the *Extruder*.
- when passing through the *Extruder* heated to 250°C, the base material will be transformed from rectangular section into round section with a diameter of 1.75mm.
- after exiting the *Extruder*, the resulting material will be coiled on the roller driven by the second stepper motor *Advance 2*, during which the resulting material will also undergo a cooling operation by the *Fan*.
- the travel speeds of the PET material is adjusted using the *Control Buttons*.
- the advance speed of the two motors and the extruder temperature can be viewed in real time on the *LCD Display*. The flow chart of operation is shown in Figure 9:

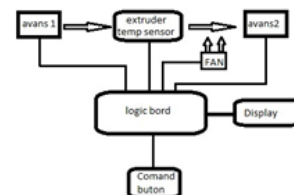


Figure 9 The flow chart of operation

All components are powered by a 12V DC power supply (8).

#### 4.3 Experimental data

The final goal of this paper is to research the mechanical characteristics of recycled PET. The method used is *Computer Assisted Thermoplastic Extrusion*[12]-[14].

First, the samples are obtained from the recycled PET flakes during printing (Figure 10, Figure 11), from which, then, the final products will be obtained. (Figure 12, Figure 13).

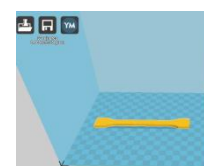


Figure 10 Design sample-horizontal print 36 minutes, 2.78m, 8 g.



Figure 11 PET samples printing



Figure 12 Types of recycled PET samples



Figure 13 Products made from recycled PET

Filament printing conditions are : temperature of nozzle and for print bed, thickness of layer, printing speed and platform material (Table 3):

Table 3. Printing conditions

Data	Value
Temperature of nozzle ( $^{\circ}$ C)	268
Temperature for print bed ( $^{\circ}$ C)	88
Thickness of layer (mm)	0.15
Printing speed (mm/min)	1980
Material of platform	glass
Flow multiplier (-)	1

These products have the mechanical and thermal characteristics of the filament used in 3D printing (details will be presented in another work).

During the testing of the properties of the materials and the adhesion of the layers, the direction of the load is respected.

For *mechanical testing* of recycled materials the testing speed was 5 mm/min. Using an extensometer the share stresses were measured for materials of recycled PET and the average obtained data was compared with the values from specialized software [ (Table 4, Figure 14).

Table 4. Mechanical testing -share stresses

Sample Material	rPET (MPa)	Soft r-PET
1	223	234
2	242	245

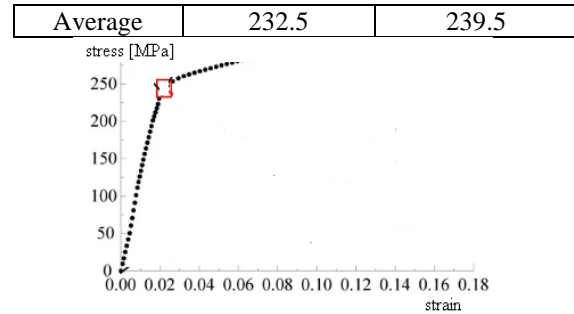


Figure 14 The diagram stress-strain

The values in the specialized literature indicate an average of 245 MPa [13], [14].

The values of elastic modulus E of the print samples for  $0^{\circ}$  and  $90^{\circ}$  bed orientation are shown in Table 5:

Table 5. Mechanical testing - elastic modulus E

Data	rPET (MPa)
$E_0$ (MPa)	1595
$E_{90}$ (MPa)	1995

For *thermal testing* were analysed the results of the heating and cooling cycle. During second heating cycle the results of measurements helped to establish the glass transition region-for rPET from  $77^{\circ}$  C to  $87^{\circ}$  C. During the heating cycles can observed the lamellar thickness distribution of the crystallites (Table 6):

Table 6. Heating cycle results

Data	rPET
Fusion Heat (J/grd)	-37.80
Crystallinity (%)	26

After finished tests some samples presented elongations and ductile fractures in compared to others [15],[16].

## 5. CONCLUSIONS

After analysing the mechanical and thermal properties of the samples obtained from recycled PET we can conclude:

- media stress is about 232.5 MPa compared to the one obtained by software 239.5 MPa;
- the values of elastic modulus E is variable from 1595 MPa (on  $0^{\circ}$  bed orientation) to 1995 MPa (on  $90^{\circ}$  bed orientation);
- during thermal tests was observed that on a value of fusion heat about (-37.80)J/grd , appear lamellar thickness distribution of the crystallites (26% crystallinity).

The properties of the samples from which the finished products were made are close to those in the industry, so the process carried out with this device can be positively validated.



Creativity starts from the students' laboratories and can lead to the certification of their results on an industrial scale.

## 6. ACKNOWLEDGMENTS

Authors gratefully acknowledge to this material support path received under Project “ Maximizing the renewable energy hosting capacity of distribution networks “(MAREHC), PNNR 760111/23.05.2023\_C48.

## 7. REFERENCES

1. Green Education, 2022, *Importanța reciclării sticlelor din polietilena tereftalată (PET)*. Available from <https://www.greeneducation.ro/colectare-deseuri/importanta-reciclarii-sticlelor-din-polietilena-tereftalata-pet/>. Accessed:11/03/2023.
- 2.\*\*\*, 2020, *Ce este PET-ul?* <https://www.renovablesverdes.com/ro/que-es-el-pet/>. Accessed:11/03/2023.
- 3.Green Tech-Global, (2022). *Reducerea CO<sub>2</sub>*. Available from <https://www.green-tech-global.com/ro/reducerea-co2>. Accessed:11/03/2023.
4. Beier Group, 2023, *PET recycling line*. Available from [https://www.beierrecycling.com/pet-recycling-line/?gclid=Cj0KCQjwsIejBhDOARIsANYqkD302WP4OOwFPyCvUH9KxnHGIXX1rUbaOqC-6NldCLRl5orm5ivAZaYaAhvxEALw\\_wcB](https://www.beierrecycling.com/pet-recycling-line/?gclid=Cj0KCQjwsIejBhDOARIsANYqkD302WP4OOwFPyCvUH9KxnHGIXX1rUbaOqC-6NldCLRl5orm5ivAZaYaAhvxEALw_wcB). Accessed 11/03/2023.
- 5.Beier Group, 2023, *PET sheet extrusion line*. Available from: <https://www.beierrecycling.com/pet-sheet-extrusion-line/>. Accessed 15/05/2023
- 6.Beier Group, 2023, *PET strap production line*. Available from: <https://www.beierrecycling.com/pet-strap-production-line/>. Accessed: 15/05/2023.
- 7.Beier Group, 2023, *PET fiber production line*. Available from: <https://www.beierrecycling.com/pet-fiber-production-line/>. Accessed 15/05/2023.
- 8.Elant,China, 2023, *Elant High quality PET recycling machine*. Available from: <https://www.elantmachine.com/Elant-High-Quality-PET-Recycling-Machine-For-Sale-3000kg-hr-pd46292761.html> .Accessed 15/05/2023
- 9.Green Tech, 2020, *PET-de la deseu la resursa*. Available from: <https://www.green-tech-global.com/ro/servicii/reciclare>.Accessed 11/03/2023.
10. Useon Technology Limited, 2022, *PET Sheet Extrusion Line*. Available from: [https://www.useon.com/pet-recycling/pet-sheet-extrusion-line/?gclid=Cj0KCQIA6rCgBhDVARIsAK1kGPIAYeD3VVChpRD6KXqnMEMO1wEq-GBZJNI-JUyGqwZLcadULvWAaHiaAvoKEALw\\_wcB](https://www.useon.com/pet-recycling/pet-sheet-extrusion-line/?gclid=Cj0KCQIA6rCgBhDVARIsAK1kGPIAYeD3VVChpRD6KXqnMEMO1wEq-GBZJNI-JUyGqwZLcadULvWAaHiaAvoKEALw_wcB). Accessed 11/03.2023.
- 11.Useon Technology Limited, 2022, *800-1200kg/h PET Sheet Production Line in Jiangsu*. Available from: <https://www.useon.com/jiangsu/>.Accessed:11/03/2023.
12. Raza S.M., Singh D., 2020, *Experimental Investigation on Filament Extrusion using recycled materials*. Available from: <http://www.diva-portal.org/smash/get/diva2:1417092/FULLTEXT02.pdf>. Accessed 11/03/2023.
13. Pittmann J., 2011, *Computer-aided design and optimization of profile extrusion dies for thermoplastics and rubber: A review*. Journal of process Mechanical engineering, 1989-1996,vol.225 (4):280-321. Available from: <https://journals.sagepub.com/doi/10.1177/0954408911415324>.
14. M.B.Seiberth, G.a.M. Capote, M. Gruber, V. Volk, T.A.. Ostwald, 2022, *Manufacturing of a PET Filament from Recycled Material for Material Extrusion (MEX)*. Available from: <https://www.mdpi.com/2313-4321/7/5/69>. Accessed 11/03/2023.
15. Marshal, I., Todd A.,1983, *The thermal degradation of polyethylene terephthalate*, Trans Faraday Soc.Journal, 43, pp.67-78.
16. Villain, F., Coudane, J., Vert, M.,1994, *Thermal degradation of poly (ethylene terephthalate) and the estimation of volatile degradation products*. Polym. Degrad. Stab. Journal, 43, pp. 431-440.
17. Popa L.V., 2021, *Waste management on board seagoing ships*. Journal of Marine Technology and Environment, vol. 1, 2021, pp 49-54, Nautica publishing House, Constanta, ROMANIA.





## YOUNG'S MODULUS OF CALCIUM-ALUMINO-SILICATE GLASSES: INSIGHT FROM MACHINE LEARNING

MOUNA Sbai Idrissi<sup>1</sup>, Ahmed El Hamdaoui<sup>1</sup>, Tarik Chafiq<sup>2</sup>, Said Ouaskit<sup>1</sup>

<sup>1</sup>Département de physique, Laboratoire de Physique de la Matière Condensée (LPMC), Faculté des Sciences Ben M'Sik, Université Hassan II de Casablanca, BP 7955, Sidi Othman, Casablanca, MAROC, email : mounasbaiid@gmail.com

<sup>2</sup>Département de géologie, Laboratoire de Physique de la Matière Condensée (LPMC), Faculté des Sciences Ben M'Sik, Université Hassan II de Casablanca, BP 7955, Sidi Othman, Casablanca, MAROC

**Abstract:** Modern technologies require the development of new materials with exceptional properties. Machine Learning (ML) and Deep Learning (DL) techniques have become important tools for discovering new materials and predicting the properties of specific materials, such as glasses. In this paper, we used ML and DL techniques to predict the Young's modulus  $E$  of Calcium-Alumino-Silicate (CAS) glasses based on their chemical composition. We evaluated four different algorithms, including Polynomial Regression (PR), Random Forest (RF), K-Nearest Neighbors (KNN), and Multi-Layer Perceptron Regressor (MLPRegressor). We found that the PR algorithm provides excellent predictions without Cross-Validation (CV), while the MLPRegressor yields the best performance when CV is implemented.

**Key words:** Calcium-Alumino-Silicate glasses, Young's modulus, Machine Learning (ML), Deep Learning (DL), Cross-Validation (CV).

### 1. INTRODUCTION

Improving the mechanical properties of glasses, particularly their stiffness (e.g., Young's modulus  $E$ ), is highly important. Glasses with high stiffness exhibit enhanced resistance to shocks and loads, rendering them safer for use in various applications such as laptop screens, mobile phones, and protective eyewear [1]. Moreover, they find wide applications in industries requiring high optical precision, including scientific instruments [2], construction, and electronic equipment [3]. Additionally, these materials play crucial roles in the immobilization of nuclear waste and aerospace technologies. [4],[5],[6]

Enhancing the stiffness of glasses is one of the most formidable tasks in the realm of physics. [3] Overcoming this challenge necessitates the discovery of new glass compositions with better-suited mechanical properties [7], [8].

However, this endeavour is exceedingly difficult due to the lack of an ordered crystalline structure and fixed stoichiometry in amorphous materials, compounded by their out-of-thermodynamic-equilibrium nature [9], which has a significant impact on the properties of glasses.

In addition to traditional experimental and simulation techniques, deep learning (DL) and machine learning (ML) have emerged as a popular method for predicting the mechanical properties of glasses [10], [11], [12]. Particularly when compared to Molecular Dynamics (MD) simulations, ML and DL methods offer

accurate results albeit with significantly reduced computational time [13]. While MD simulations may require weeks or even months on supercomputers to simulate the mechanical properties of numerous glasses with varied chemical compositions, ML and DL techniques can accomplish the same task within seconds or minutes. [13].

Notably, both molecular dynamics simulations and artificial intelligence simulations have their own advantages and disadvantages, and they can be considered complementary methods. In this study, we apply ML and DL techniques to predict the Young's modulus of the Calcium-Alumino-Silicate (CAS) glass system, with and without cross-validation, and compare the performance of the applied models. The CAS system stands as one of the most extensively studied silicate glass-forming systems, both experimentally and through simulation, owing to its unique optical and mechanical properties, which render it industrially relevant. [14], [15], [16].

This paper is structured into three sections.

*The first section* focuses on the methodology of the learning algorithms applied to our dataset for predicting the Young's modulus.

*The second section* presents the results obtained and their interpretations for each model.

*Lastly*, the concluding section summarizes the findings.

## 2. METHODOLOGY

### 2.1 Data Set:

The data set used for prediction includes Young's modulus values for a set of 231 different chemical compositions of  $(\text{CaO})_x(\text{Al}_2\text{O}_3)_y(\text{SiO}_2)_{1-x-y}$  glassy systems, with  $0 \leq x \leq 1$ ,  $0 \leq y \leq 1$  incremented by 0.05 for both parameters, as depicted in the ternary diagram shown in figure 1. To explain the input variables (or features) of our data set, one should first explain the chemical composition of the CAS glasses, which are composed of Alumino-Silicates with Calcium cations to form a ternary system  $\text{CaO}/\text{Al}_2\text{O}_3/\text{SiO}_2$ . Therefore, our data set contains the concentrations (% mol) for the three chemical compositions, with an increment of 5%. The only output variable (or target) is Young's modulus  $E$  in GPa. The 231 values of  $E$  were obtained from high-throughput molecular dynamics simulations (DM) study of CAS glasses by Yang and al[17]. The polymeric structure of these glasses is based on the presence of an aluminate and silicate tetrahedral network that shares corners.

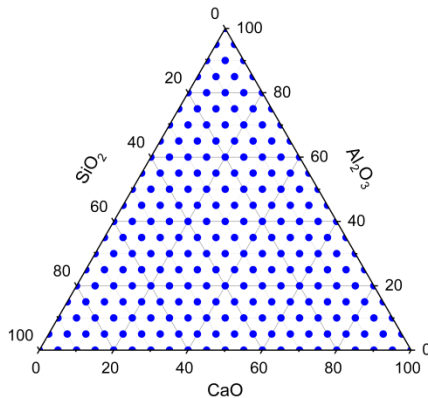


Figure 1 Ternary diagram of the chemical composition of CAS glasses obtained from high-throughput molecular dynamics simulations by Yang and al [17]: Visualization of the percentage concentration of silica, alumina, and calcium oxide elements.

### 2.2 Learning Algorithms:

We implemented four supervised learning algorithms on our data set: K-Nearest Neighbors (KNN), Random Forest (RF), Polynomial Regression (PR), and Multi-Layer Perceptron (MLP).

The data was divided into a training set (75%) and a test set (25%) with a random splitting. The performance of the models was evaluated based on this initial split.

Following the initial evaluation, we employed K-fold Cross-Validation to assess the effect of cross-validation

on each algorithm's performance. this technique further divide the training set into sub-training and validation sets[18], [19]. In this process, the training data was divided into four equal-sized blocks, and during each iteration, one block was used as the validation set, while the other three blocks were used for training[18], [19], [20]. The performance of the model was then evaluated on the current validation set and the overall performance was determined by combining the results from each iteration.

This approach allowed us to observe how the inclusion of cross-validation impacted the behavior and performance of each algorithm.

It's important to note that the initial study involved algorithms evaluated without cross-validation, with performance assessment solely based on the initial training and test split.

### 2.3 Data Evaluation:

In this work, we evaluate the performance of four different learning algorithms: (KNN), (RF), (PR), and (MLP). Our goal is to understand each model's behavior and performance and to find the best hyperparameters for each algorithm, this involves finding the number of nearest neighbors, the number of trees, the polynomial degree, and the number of neurons for KNN, RF, PR, and MLP respectively. To evaluate the performance of the different models, we use two metrics: the Root Mean Squared Error (RMSE) (Eq.1), and the coefficient of determination  $R^2$  which is the squared correlation coefficient (Eq.2). The model that offers the best performance is the one with the lowest test RMSE and an  $R^2$  close to 1 [21].

$$\text{RMSE} = \sqrt{\frac{1}{n} \sum_{i=1}^n (Y_i - \hat{Y}_i)^2} \quad (1)$$

Correlation coefficient :

$$R = \frac{\sum_{i=1}^n (Y_i - \bar{Y}_i)(\hat{Y}_i - \bar{\hat{Y}}_i)}{\sqrt{\sum_{i=1}^n (Y_i - \bar{Y}_i)^2 \sum_{i=1}^n (\hat{Y}_i - \bar{\hat{Y}}_i)^2}} \quad (2)$$

Coefficient of determination =  $R^2$

$Y_i$ ,  $\hat{Y}_i$ ,  $n$ ,  $\bar{Y}_i$ ,  $\bar{\hat{Y}}_i$ , are the measured (real) value of observation  $i$ , the predicted value of observation  $i$  by the model, the number of observations, the mean of the measured (real) value of observation  $i$ , and the mean of the predicted value of observation  $i$  by the model, respectively.

## 3. RESULTS

### 3.1 K-Nearest Neighbors:

The KNN model uses the number of nearest neighbors ( $k$ ) as an important hyperparameter [22]. Fig.2(a) shows the RMSE values for the test and training

sets as a function of  $k$ , with and without CV. For low values of  $k$ , we observe that the RMSE of test set are higher than that of training set, which indicate that the model is overfitting to the training data and not generalizing well to unseen data [23]. By increasing the value of  $k$ , the RMSE of the training set increases and the RMSE of the test set decreases until reaching a value of  $k$  equal to 4. Beyond 4, we observed that the RMSE of both the training and test sets increased, indicating that the model is unable to fit the training data well enough to offer good performance on the test data, which is known as underfitting. In this model, the complexity varies depending on several factors, including the number of neighbors ( $k$ ) considered for predicting a point, the dimensionality of the space in which the data resides, and the total number of points in the dataset. Regarding the number of neighbors ( $k$ ), the complexity of the KNN model generally increases with  $k$ . This is because in order to predict the class of a point, the model needs to find the  $k$  nearest points in the data set, which can be computationally expensive if  $k$  is large. However, a value of  $k$  that is too small can also lead to insufficient model performance [22], [23], [24], [25]. Indeed, we found that  $k$  equal to 4 provides a minimum for the test RMSE, which is 3.36 (GPa). Therefore,  $k$  equal to 4 is the optimal value for this model. We now focus on evaluating the accuracy of the KNN model using the determination coefficient  $R^2$  for the test set, with and without CV. Figure 2(b) shows that for  $k=4$ , the highest  $R^2$  scores without cross-validation and with cross-validation are respectively 0.96 and 0.94.

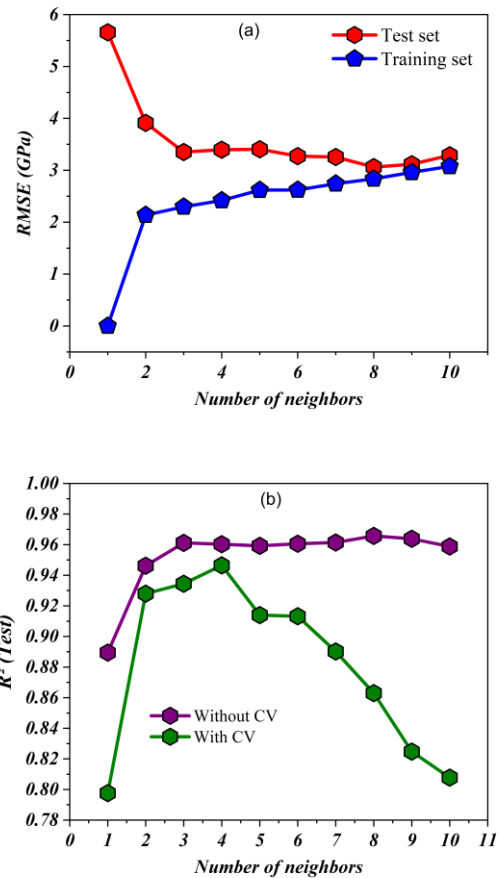


Figure 2

(a) RMSE of the KNN model as a function of the number of nearest neighbors as obtained for the training and test set;

(b) The influence of the number of nearest neighbors on the performance of the KNN model: Comparison of the determination coefficients obtained with and without CV.

### 3.2 Random Forest:

In this model, we focused on the effect of the number of trees in a random forest on performance. The results illustrated in Figure 3(a) demonstrate that the RMSE for the test and training sets shows a small variation with the number of trees, with and without CV. No overfitting or underfitting is observed, which is due to the simplicity of this model. We find 100 trees as the optimal hyperparameter that provides a minimum RMSE [20], [26] of 2.904 GPa for the test data. When evaluating the accuracy of the (RF) model using the  $R^2$  determination coefficient for the test set, Figure 3(b) shows that the highest scores are obtained when the number of trees used is equal to 100. Using CV, the score obtained is 0.933, while in the absence of CV, the score obtained is 0.970. These results show that the use

of CV has an impact on the model accuracy, but the number of trees used remains an important factor in achieving the best performance.

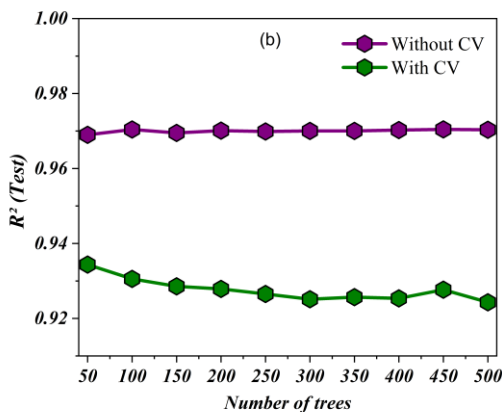
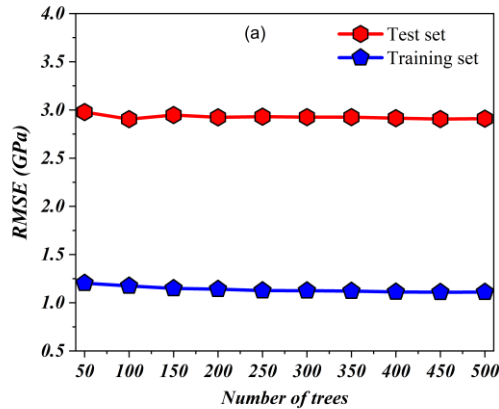


Figure 3

(a) RMSE of the RF model as a function of the number of trees as obtained for the training and test set;

(b) Influence of the number of trees on the performance of the RF model: Comparison of the determination coefficients obtained with and without CV.

### 3.3 Polynomial Regression:

We used the PR to train our data, selecting polynomial degrees ranging from 1 to 10. Figure 4(a) depicts the RMSE for both training and test data as a function of polynomial degrees. The RMSE values for training data are clearly lower than those for test data as shown in Figure 4(a). For low polynomial degrees, the high RMSE values for both sets indicate that the model is too simple to accurately represent the relationship between Young's modulus and the chemical composition of CAS glasses, leading to underfitting. As the polynomial degree increases, the RMSE values decrease

until reaching a minimum value of 2.41 GPa for the test data at degree 5. Beyond this point, the test RMSE begins to increase again, which means the model has overfit. Therefore, the optimal polynomial degree is 5, which offers the best performance both with and without CV Figure 4(b).

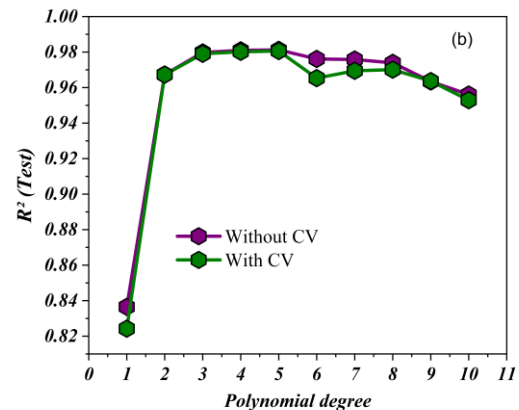
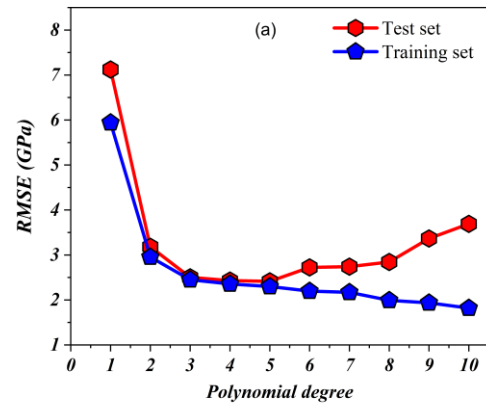


Figure 4

(a) RMSE of the PR model as a function of the polynomial degree for training and test sets;

(b) Influence of the polynomial degree on the performance of the PR model: Comparison of determination coefficients obtained with and without CV.

### 3.4 Multilayer Perceptron:

This DL model based on neurons [27], [28], [29], [30] consists of a single hidden layer with a number of neurons ranging from 50 to 500, incremented by 50, and a single output neuron. The activation function chosen for the hidden layer is the "relu" function that returns " $f(x) = \max(0, x)$ ", the maximum between 0 and x [31]. Figure 5(a) shows the performance of the MLP model in terms of RMSE for the training and test sets as a

function of the number of neurons, with and without CV. It is clear that the MLP model does not show notable overfitting. When the number of neurons is 50, the RMSE for the test data is at a minimum, which means that 50 neurons is the optimal hyperparameter for this model. When evaluating the performance of the MLP model using the  $R^2$  determination coefficient for the test set, Figure 5(b) shows that the highest scores are obtained with 50 and 150 neurons respectively without and with CV. The use of CV increased the model's accuracy score from 0.975 to 0.987. These results indicate that the number of neurons used and the use of CV have a significant impact on the accuracy of the MLP model.

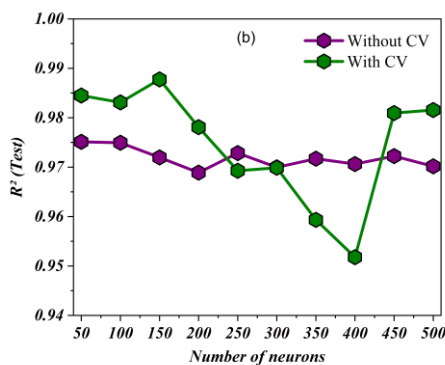


Figure 5

- (a) RMSE of the MLP model as a function of the number of neurons for training and test sets;  
(b) The influence of the number of neurons on the performance of the MLP model: Comparison of determination coefficients obtained with and without CV.

#### 4. DISCUSSION

In this section, we will discuss the results obtained by different DL and ML algorithms with and without CV. Table 1. presents the  $R^2$  determination coefficient values obtained for each algorithm on the test set, which measures the algorithm's ability to predict unknown data and thus the accuracy of the model. We found that the KNN-algorithm offers an accuracy of 96% without CV and 94% with CV. The RF-algorithm of Trees model gives an accuracy of 97% without CV and 93% with CV. The MLP and PR algorithms have a similar accuracy, although the PR-algorithm has slightly higher accuracy at 98.12% without CV. Finally, we observe that the MLP-algorithm provides the highest accuracy with a CV of 98.77%.

It is important to note that ML algorithms are generally easier to understand and interpret than deep neural networks, but the latter tend to give more accurate results in many cases, such as image recognition[28]. It is therefore important to choose the right type of algorithm depending on the precision requirements. The

KNN, RF, and PR machine learning models have better performance without CV than with it. This may be due to the small size of the used data set (231 samples) [32], [33] which can reduce accuracy when CV is used. It is also possible that the CV for training data is more representative of the test data set, which can result in better performance. However, for some algorithms such as RF, the overfitting is not observed, which means it can work without CV [32].

It is important to note that CV is a technique used to evaluate the performance of models using sub-training data that has not been used for training, but it is not always necessary or beneficial for all models and data sets. For DL models such as MLP, the performance is usually better with CV due to the complexity of these models[34].

Figures.6(a)-(b) show the predicted young's modulus (E) values by PR without cross-validation (with a degree of 5) and by MLP with cross-validation (with 150 neurons) in comparison with the simulated young's modulus values by high-throughput molecular dynamics simulations in (GPa), respectively. Therefore, these models are the most effective and can ameliorate the prediction of the relationship between the chemical composition and young's modulus of the CAS glass system.

Table 1. Comparison of performance of different learning algorithms: Coefficient of determination obtained without and with CV for the entire test data for each model

Algorithmes d'apprentissage	$R^2$ (test)	
	Sans CV	Avec CV
KNN	0.960	0.946
RF	0.970	0.930
PR	0.981	0.980
MLP	0.975	0.984

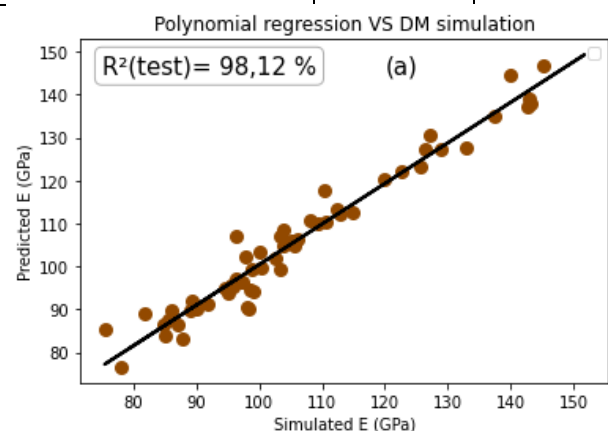


Figure 6 (a) Comparison between the predicted Young's modulus values by PR (degree = 5) without cross-validation and those calculated by molecular dynamics simulations

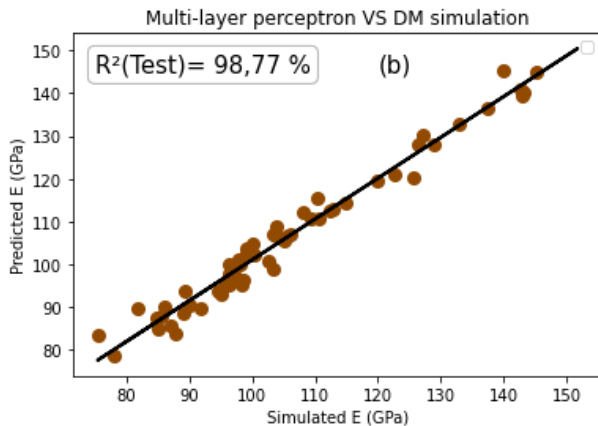


Figure 6 (b) Comparison between the predicted young's modulus values by MLP with cross-validation (number of neurons = 150) and those calculated by molecular dynamics simulations.

## 5. CONCLUSION

Overall, this paper examines how artificial intelligence approaches can be used to discover and predict new mechanical properties of glasses (Young's modulus) without relying on computer simulation techniques based on numerical calculations. The learning algorithms are flexible and easy to use.

Upon application to our dataset, the MLP algorithm with cross-validation exhibits the highest performance. Conversely, the PR algorithm achieves optimal results without cross-validation, specifically with a polynomial degree of 5. This disparity in performance highlights an interesting observation regarding the impact of cross-validation on machine learning algorithms compared to deep learning algorithms. The simplicity of the machine learning algorithms appears to render them less sensitive to the effects of cross-validation, whereas deep learning algorithms may benefit more significantly from such validation techniques. This distinction underscores the nuanced relationship between model complexity, algorithmic simplicity, and the efficacy of cross-validation methodologies in optimizing predictive performance.

However, further applications of ML and DL algorithms are required to examine different types of silicate glasses (binary and ternary) in order to reach a general conclusion on the use of these methods in predicting the properties of glassy materials.

## 6. REFERENCES

[1] S. Bishnoi *et al.*, "Predicting Young's modulus of oxide glasses with sparse datasets using machine learning," *Journal of Non-Crystalline Solids*, vol. 524, p. 119643, Nov. 2019, DOI 10.1016/j.jnoncrsol.2019.119643.

[2] "Bulk elastic properties, hardness and fatigue of calcium aluminosilicate glasses in the intermediate-silica range - *ScienceDirect*." Accessed: Mar. 05, 2024. [Online]. Available: <https://www.sciencedirect.com/science/article/pii/S0022309315302829>

[3] J. C. Mauro and E. D. Zanotto, "Two Centuries of Glass Research: Historical Trends, Current Status, and Grand Challenges for the Future," *International Journal of Applied Glass Science*, vol. 5, no. 3, pp. 313–327, 2014, doi: 10.1111/ijag.12087.

[4] "Glasses-for-Nuclear-Waste-Immobilization.pdf." Accessed: Mar. 05, 2024. [Online]. Available: [https://www.researchgate.net/profile/Michael-Ojovan/publication/267700284\\_Glasses\\_for\\_Nuclear\\_Waste\\_Immobilization/links/5465a9240cf2f5eb17ff42de/Glasses-for-Nuclear-Waste-Immobilization.pdf](https://www.researchgate.net/profile/Michael-Ojovan/publication/267700284_Glasses_for_Nuclear_Waste_Immobilization/links/5465a9240cf2f5eb17ff42de/Glasses-for-Nuclear-Waste-Immobilization.pdf)

[5] C. I. Merzbacher, B. L. Sherriff, J. S. Hartman, and W. B. White, "A high-resolution 29Si and 27Al NMR study of alkaline earth aluminosilicate glasses," *Journal of Non-Crystalline Solids*, vol. 124, no. 2, pp. 194–206, Oct. 1990, doi: 10.1016/0022-3093(90)90263-L.

[6] M. Toozandehjani, N. Kamarudin, Z. Dashtizadeh, E. Y. Lim, A. Gomes, and C. Gomes, "Conventional and Advanced Composites in Aerospace Industry: Technologies Revisited," *American Journal of Aerospace Engineering*, vol. 5, pp. 9–15, Feb. 2018, doi: 10.11648/j.ajae.20180501.12

[7] "Decoding the glass genome - *ScienceDirect*." Accessed: Mar. 05, 2024. [Online]. Available: <https://www.sciencedirect.com/science/article/abs/pii/S1359028617301249>

[8] "Machine learning predictions of Knoop hardness in lithium disilicate glass-ceramics, Wilkinson, 2023, *Journal of the American Ceramic Society*, Wiley Online Library. Accessed: Mar. 05, 2024. [Online]. Available: <https://ceramics.onlinelibrary.wiley.com/doi/abs/10.1111/jace.19016>

[9] A. K. Varshneya, *Fundamentals of Inorganic Glasses*. Elsevier, 2013.

[10] A. W. Abboud, D. P. Guillen, and B. A. Christensen, "Prediction of melter cold-cap topology from plenum temperatures with computational fluid dynamics and machine learning," *International Journal of Ceramic Engineering & Science*, vol. 4, no. 4, pp. 257–269, 2022, doi: 10.1002/ces2.10134.

[11] M. A. Kraus and M. Drass, "Artificial intelligence for structural glass engineering applications —



- overview, case studies and future potentials,” *Glass Struct Eng*, vol. 5, no. 3, pp. 247–285, Nov. 2020, doi: 10.1007/s40940-020-00132-8.
- [12] M. Drass, H. Berthold, M. A. Kraus, and S. Müller-Braun, 2021. “*Semantic segmentation with deep learning: detection of cracks at the cut edge of glass*,” *Glass Struct Eng*, vol. 6, no. 1, pp. 21–37, doi: 10.1007/s40940-020-00133-7.
- [13] J. Singh and S. Singh, 2022, “*A review on Machine learning aspect in physics and mechanics of glasses*,” *Materials Science and Engineering: B*, vol. 284, p. 115858, Oct. 2022, DOI: 10.1016/j.mseb.2022.115858.
- [14] “*Formation and Properties of Calcium Aluminosilicate Glasses*”, SHELBY, 1985, *Journal of the American Ceramic Society*, Wiley Online Library. Accessed: Mar. 05, 2024. [Online]. Available: <https://ceramics.onlinelibrary.wiley.com/doi/abs/10.1111/j.1151-2916.1985.tb09656.x>
- [15] M. E. Lines, J. B. MacChesney, K. B. Lyons, A. J. Bruce, A. E. Miller, and K. Nassau, 1989, “*Calcium aluminate glasses as potential ultralow-loss optical materials at 1.5–1.9 μm*,” *Journal of Non-Crystalline Solids*, vol. 107, no. 2, pp. 251–260, Jan. 1989, doi: 10.1016/0022-3093(89)90470-5.
- [16] F. T. Wallenberger and S. D. Brown, “*High-modulus glass fibers for new transportation and infrastructure composites and new infrared uses*,” *Composites Science and Technology*, vol. 51, no. 2, pp. 243–263, Jan. 1994, Doi: 10.1016/0266-3538(94)90194-5.
- [17] K. Yang et al., 2019, “*Predicting the Young’s Modulus of Silicate Glasses using High-Throughput Molecular Dynamics Simulations and Machine Learning*,” *Sci Rep*, vol. 9, no. 1, p. 8739, Jun. 2019, Doi: 10.1038/s41598-019-45344-3.
- [18] R. Kohavi, 2001, “*A Study of Cross-Validation and Bootstrap for Accuracy Estimation and Model Selection*,” vol. 14.
- [19] Z. Nematzadeh, *Comparative Studies on Breast Cancer Classifications with K-Fold Cross Validations Using Machine Learning Techniques*. 2015.
- [20] G. Battineni, G. G. Sagaro, C. Nalini, F. Amenta, and S. K. Tayebati, 2019, “*Comparative machine-learning approach: A follow-up study on type 2 diabetes predictions by cross-validation methods*,” *Machines*, vol. 7, no. 4, p. 74.
- [21] T. Oey, S. Jones, J. W. Bullard, and G. Sant, 2020. “*Machine learning can predict setting behavior and strength evolution of hydrating cement systems*,” *J Am Ceram Soc*, vol. 103, no. 1, pp. 480–490, Doi: 10.1111/jace.16706.
- [22] Z. Zhang, 2024, “*Introduction to machine learning: k-nearest neighbors*,” *Annals of translational medicine*, vol. 4, no. 11, 2016, Accessed: Mar. 06, 2024. [Online]. Available: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4916348/>
- [23] “*Overfitting and Underfitting Analysis for Deep Learning Based End-to-end Communication Systems*” *IEEE Conference Publication | IEEE Xplore*. Accessed: Mar. 06, 2024. [Online]. Available: <https://ieeexplore.ieee.org/abstract/document/8927876>
- [24] S. K. Ahmmad, N. Jabeen, S. T. U. Ahmed, S. A. Ahmed, and S. Rahman, 2021, “*Artificial intelligence density model for oxide glasses*,” *Ceramics international*, vol. 47, no. 6, pp. 7946–7956.
- [25] S. Huang, M. Huang, and Y. Lyu, 2020, “*An Improved KNN-Based Slope Stability Prediction Model*,” *Advances in Civil Engineering*, vol. 2020, p. e8894109, Jul. 2020, doi: 10.1155/2020/8894109.
- [26] L. Yang, K. Jia, S. Liang, J. Liu, and X. Wang, 2016, “*Comparison of four machine learning methods for generating the GLASS fractional vegetation cover product from MODIS data*,” *Remote Sensing*, vol. 8, no. 8, p. 682, 2016.
- [27] A. Nguyen, K. Pham, D. Ngo, T. Ngo, and L. Pham, 2021, “*An analysis of state-of-the-art activation functions for supervised deep neural network*,” in *2021 International Conference on System Science and Engineering (ICSSE)*, IEEE, pp. 215–220. Accessed: Mar. 06, 2024. [Online]. Available: <https://ieeexplore.ieee.org/abstract/document/9538437/>
- [28] D. Jakhar and I. Kaur, 2020, “*Artificial intelligence, machine learning and deep learning: definitions and differences*,” *Clinical and experimental dermatology*, vol. 45, no. 1, pp. 131–132.
- [29] S. Abirami and P. Chitra, 2020, “*Energy-efficient edge based real-time healthcare support system*,” in *Advances in computers*, vol. 117, Elsevier, pp. 339–368. Accessed: Mar. 06, 2024. [Online]. Available: <https://www.sciencedirect.com/science/article/pii/S0065245819300506>
- [30] I.-C. Yeh, 1998 “*Modeling of strength of high-performance concrete using artificial neural networks*,”



---

Cement and Concrete research, vol. 28, no. 12, pp. 1797–1808.

[31] D. Roche, 2024, “*Deep Learning et apprentissage par renforcement pour la conception d’une Intelligence Artificielle pour le jeu Yokai No Mori*,” Ce travail est publié sous licence Creative Common, Accessed: Mar. 06, 2024. [Online]. Available: <https://www.epi.asso.fr/revue/articles/a1905d.pdf>.

[32] H. Blockeel and J. Struyf, 2002, “*Efficient algorithms for decision tree cross-validation*,” *Journal of Machine Learning Research*, vol. 3, no. Dec, pp. 621–650.

[33] G. Varoquaux, 2018, “*Cross-validation failure: Small sample sizes lead to large error bars*,” *Neuroimage*, vol. 180, pp. 68–77.

[34] Jason Brownlee , 2024, “*Better Deep Learning: Train Faster, Reduce Overfitting, and Make Better* , Google Livres. Accessed: Mar. 06, 2024. [Online]. Available: [https://books.google.co.ma/books?hl=fr&lr=&id=T1-nDwAAQBAJ&oi=fnd&pg=PP1&dq=Better+deep+learning:+train+faster,+reduce+overfitting,+and+make+better+predictions&ots=tENTfoj0FX&sig=\\_3tyCki2fS3E9FBOCYvII7M8Or0&redir\\_esc=y#v=onepage&q=Better%20deep%20learning%3A%20train%20faster%2C%20reduce%20overfitting%2C%20and%20make%20better%20predictions&f=false](https://books.google.co.ma/books?hl=fr&lr=&id=T1-nDwAAQBAJ&oi=fnd&pg=PP1&dq=Better+deep+learning:+train+faster,+reduce+overfitting,+and+make+better+predictions&ots=tENTfoj0FX&sig=_3tyCki2fS3E9FBOCYvII7M8Or0&redir_esc=y#v=onepage&q=Better%20deep%20learning%3A%20train%20faster%2C%20reduce%20overfitting%2C%20and%20make%20better%20predictions&f=false)





## HUNTING FOR GENIUS. WHAT IS BRILLIANCE? CAN A.I. BE BRILLIANT?

NUTU Catalin Silviu <sup>1</sup>

<sup>1</sup>Constanta Maritime University, Faculty of Naval Electro-Mechanics, 104 Mircea cel Batran Street, 900663, Constanta, Romania, e-mail: nutu\_catalin@yahoo.com

**Abstract:** This paper concerns the common features exhibited by geniuses and the ingredients which forms the recipe for a genius. It analyses the creativity of some of the most remarkable geniuses of mankind who have generated scientific theories and inventions, which brought our civilization further and further, in both, technology and in understanding our Universe. It presents what these geniuses had in common and what differentiated them from the common people, and also how they succeeded to achieve what they created. In its last section, this paper analyses the question whether A.I. could be brilliant or not and gives extensive explanations for the verdict regarding the potential brilliance of A.I.

**Keywords:** genius, brilliance, creativity, problem solving, invention, madness, craziness, A.I.

### 1. INTRODUCTION

*“Magic theater,  
Entry is not allowed to anyone...  
Only for crazy people ..”*

Quoted from „The Steppenwolf” by H. Hesse, Nobel [6]  
Prize Laureate for literature

People often times think about geniuses that they are those who effortlessly solve problems or came up with brilliant ideas, out of nothing, and can invent things or discover scientific theories, almost without any effort, based on their capacities and brilliance. But nothing is further from truth than that.

Real geniuses whose names remain for eternity have the ability to work harder than the other ones around them and to focus on the problems they want to solve.

This has been stated Einstein, according to whom: “genius is 5 percent inspiration and 95 percent transpiration”, and it is also historically confirmed, because in the same time with Einstein, there was an American contemporary with him, William James Sidis, who was presumably the most intelligent person and had an I.Q. much higher than that of Einstein, but he achieved, despite his intelligence, almost nothing and is long time forgotten while Einstein is recognized to be one of the most remarkable geniuses.

What differentiated them? It is exactly the work and effort which has been made by Einstein in comparison with Sidis, and this fact has been brilliantly intuited by Einstein when he made the above statement.

### 2. WHAT IS BRILLIANCE?

Human mind is not made to work at high frequencies, in high excitation states, usually determined either by special features of one’s brain or by stress factors like sleep deprivation or drugs abuse. Once entered in such a high frequency or high excitation state of mind, human brain is able to make connections and to find and explore ideas which are not available to common people.

Some of the ones entering such brain excitation states can hugely benefit of those states of mind either by having highly creative thoughts and creating amazing inventions or by finding solutions to great problems of science and technology.

Some others are entrapped in those states of minds, with no benefit at all, and these ones are usually forced shut down by tranquilizing medical treatments designated to reset them.

Some of them, however, refuse treatment because of the unusual sensations and richness of the world they discover when experiencing these states of mind.

But the most brilliant ideas can be generated during these controlled high frequency states of mind. Some of the ones able to master somehow those high frequency states of mind of theirs and to use them to create inventions or to solve problems are the most creative and brilliant people; they are the real geniuses of the mankind.

Very few people, however, have this amazing ability to control their high frequency states of mind. It is believed that one of the geniuses able to control these high excitation states of mind and to use them to create



outstanding inventions was the brilliant N. Tesla, who was presumably taught, since early childhood, by his mother, to control his creative states of mind.

Reverting to the question: "What did all geniuses have in common?", it seems that their success is almost always determined by their work and their effort to pursue a certain idea or goal.

They are mostly autodidacts who study and know all what is related to their purpose and they have the capacity to absorb all the information related to their scientific goal.

Another common feature of the geniuses is that they all had extraordinary and unusual intellectual abilities, which on one hand permitted them to have such brilliant ideas and on the other hand allowed them to focus on the solving of their problems, much better than average people, in order to make such new extraordinary discoveries.

These unusual intellectual abilities of theirs caused by their brains differently wired than in the case of common people, can hardly be understood by common people, and these abilities made common people to regard the geniuses as weird, freaky or even crazy or mad persons.

The lives of these highly creative people were many times spectacular and abundant in strange and inexplicable happenings, facts and phenomena, such as presented in [1], [2], [3], [4] and [5].

Common people also give less thought to the fact that in crisis situations, not ordinary normal people are those who solve problems and come up with the solutions, but instead these unusual persons, exactly like in the case of Alan Turing.

### 3. FEATURES OF THE MOST CREATIVE GENIUSES

It seems that all great creative geniuses share in common one or more of the following features which make them remarkable:

1) Ability of their brain to work at high frequencies or in high excitation states, generated during sleepless nights, as in the case of Tesla, previously trained by his mother to deal with these issues. However, although many may experience such unusual states of mind, rather few have the ability to use them for creative purposes, so the ability to create in such high frequency states is not available to anyone.

2) Ability to think unconventionally, out of the box, and to relentlessly persist on an idea or onto searching a solution to a problem they want to solve, exactly like in the case of A. Einstein.

3) Ability to make huge efforts and to work very hard to relentlessly pursue an idea or a goal related to an invention or to the solution to a problem

4) Ability to be autodidact and experiment a lot. It seems that the ability of these people to be autodidact and to acquire a lot of knowledge in their area of interest is of paramount importance for their discoveries, since

many of them reject the usual education forms and replace the higher education by their own targeted hard autodidact work. All of them had an unquenched and unstoppable passion to read and to acquire as much information as possible.

Reading of immense amounts of scientific but also non-scientific literature seriously increases the capacity to imagine things and phenomena and also often enables connections between different ideas only apparently not connected with each other, thus often resulting important inventions.

They read not only into their fields of specialty but in very many adjacent fields, since many great ideas are generated also by brilliant people who are not acting in the field of science but for example in the field of literature, such as presented in [6].

It is known that Tesla, after finishing the Polytechnic University also finished the Faculty of Philosophy, [2], and Einstein also had a great interest in the philosophy and in the philosophic ideas related to science, fact which helped him to generate his renowned Relativity Theory, as presented in [3].

However, many of these people who followed higher education programs declared that the respective university programs had no contribution to the success in their lives, but nevertheless they are making such statements despite the fact that they followed the respective university programs. No one could know whether they would realize what they had in the absence of their higher education training or how this training has impacted them and formed their minds.

However, either if the respective knowledge is acquired in the school or by being autodidact, its acquiring is paramount, not only because of the information therein which helps the problem solver or inventor, but also because during an intellectual activity of any type, new connections in the brain are made and the mind is thus permanently modelled by such an intellectual activity.

The knowledge and information of their interest are not only in their fields of study for their problems, but they are reading and learning also in the other related neighbouring fields, fact which additionally develops their thinking and their ability to think in more than one simple science. This interdisciplinary thinking of them, develops their brain, on one hand, and increases their success chances, on the other.

5) Based on their acquired knowledge, they can come up with outstanding solutions to problems or inventions, even during their sleep.

6) Based on their acquired knowledge, they can come up with outstanding solutions to problems or inventions during their sport activities, when brain is detached of many of its tasks and rests and thoughts are freely wandering.

7) Sometimes, there are people who only have sheer luck combined with the ability to experiment and find solutions, purely based on their experience. But



these cases are rather rare by comparison with the other cases presented.

8) And finally, there are also some cheaters, who are actually false geniuses, which can also be creative people. They are lacking the abilities of brains of real geniuses and are cheating, by feeding their brains with drugs and substances able to stimulate and transpose them into the creative states of mind of the real

#### 4. MADNESS AND FURY OF THE GENIUS

There is a renowned line in the “Braveheart” Hollywood Oscar rewarded movie which says: “Often times history has been written by those who have hanged heroes”. In the very same way, the history of science and of technology has been written by those who were considered crazy by their fellow countrymen or by people contemporaries with them.

Mankind almost always mocked its geniuses but the “normal average” people knew to exploit, to profit and to take advantage of those mad and crazy geniuses and of their remarkable work. They looked to them as to some kind of weirdos, completely not understanding how their lives would have been without the brilliant inventions of those special people.

These highly creative and brilliant people having the ability to find solutions to the great problems of science or having the ability to make amazing inventions, are often regarded as impertinent and not submissive. They are often not adapted persons who hardly compromise or have poor abilities to compromise and they are rarely and barely assimilated by the world and by general trends in society. This is why they are regarded not very friendly by their fellow contemporaries and they are often considered to have annoying personalities for the others.

They think and act unconventionally and many times in ways which are not understandable for the other common people.

They mostly orientate themselves according to their convictions and to their beliefs and not according to the common trends.

They isolate themselves out of more reasons: they are not understood by the ordinary people, they are relentlessly preoccupied of their problems they want to solve and they do not follow the crowd or the herd because are too intelligent for it and have no interest in the small interests of the common people.

Because of the differences and oppositions to the “world”, presented above, they often virtually become martyrs which are socially and even physically eliminated by their fellow citizens, like it is presented later in a few examples in this paper.

Few people today realize how much we owe to the geniuses who brought mankind such technologically advanced, and they also hardly realize that much of the things we take nowadays for granted were the result of the effort and of the brilliance of such “weird” persons.

natural geniuses. This is mainly the case of people involved in literature or songs writing or of some painters, and it is much rarely the case for people within the field of science.

Without them, perhaps mankind would have nowadays still struggled with stones and wooden sticks as its only main tools.

Reverting to the most remarkable brilliant people mankind has had, it is known that A. Einstein had a slightly schizotypal personality and a disorder named Asperger syndrome which allowed him to focus, for a lot of time on the very same problem, problem which eventually he actually solved it. His son also suffered from a similar related medical condition.

N. Tesla was barely sleeping and he envisioned his inventions in very peculiar ways, in the form of lights and colours, as if they were virtually “transmitted” to him. Tesla admitted that he had a nervous breakdown after finishing his studies at the University and while this malady he had envisioned many “strange and unbelievable phenomena” [2].

He often envisioned “flashes of light” and also had some very odd perceptions and sensations, closely at the edge with hallucination phenomena, and he also admits that for much of the time of his life he lived in his mind, by traveling a lot by the power of imagination into worlds unknown to him. This fact developed his ability to imagine things which later helped him to the design of his inventions.

Apart from that, his brain had an unusual capacity to work like a computer running a CAD software. He was able to add, build and remove components and parts of his imaginary inventions he designed in his mind, exactly like a computer does it.

He also admits that “all these early afflictions had however, another compensation”, as presented in [2]. This compensation was his brilliant ability to make inventions.

Mihai Eminescu, our most remarkable national genius, had also his periods of madness and two of his aunts from the mother side, Olimpia and Fevronia, lived at the Agafton Monastery in Moldova.

Despite of their brilliance, many of these geniuses, had pitiful human vices. Only to name two of them, both, Tesla and Dostoyevsky had the vice of gambling, but, with time, they also had the power to control their vices. In this light the saying of Dostoyevsky, admitting that “very intelligent people can make very foolish things”, keeps very well its validity.

At a closer look, almost any genius which created important inventions or solved serious problems, had



some kind of mental condition and it seems that this is the main ingredient of the most creative minds.

But unfortunately, not understanding the contribution of these people and very much used with their own dirt, the common people, lovers of scandal, are very used to scratch dirt and to rummage the trash, as their main activity and occupation, very much forgetting the contribution of these geniuses, and wanting to degrade them at their own level, out of envy for their achievements.

Part of this denigration of geniuses is also because of their un-negotiability and their lack of compromising. Geniuses, many times also bring, in return, to the light, the dirt and the true face and the truths of their societies, exactly like in the case of our national genius, Mihai Eminescu.

That is why, many of those uncompromising and un-negotiable geniuses are not ending well and very often they not die of natural deaths.

Visionary leaders having exceptional achievements and outstanding outcomes, like the Romanian prince, Michael the Brave (Mihai Viteazul), are also considered as crazy. Mihai Viteazul was considered at his time, by western powers and offices, as having “a crazy courage” in opposing and fighting the ottoman empire at that time, around 1600 a.D.

Both of them, Mihai Eminescu and Mihai Viteazul as well, shared the very same fate, namely they have been betrayed and killed by their own fellow countrymen.

It is also very known the case of the Romanian revolutionary Avram Iancu, a brilliant Romanian lawyer which was one of the main organizers of the Romanian revolution from 1848, and had the courage and the “impertinence” to defy the Austrian emperor Franz Joseph.

Moreover, as if all this above it is not enough, the discoveries of these geniuses are most often contradicted by those small common people, not understanding a little bit of the thoughts of these giants of thinking.

Their theories are deemed many times as outrageous and these brilliant people are to face again the dirt, until their sun shines and shows the truth to the world. Many times, however, their theories are confirmed long time thereafter, sometimes, tragically for them, even after their death.

It is already known fact and history, that also, many times, these brilliant people offering freely the understanding of our Universe, or giving to mankind their most valuable inventions are used or even misused for other low interests, purposes or propaganda, by small politicians or other people, eager to attract attention not on these geniuses of mankind, but rather on themselves.

Instead of being grateful for those brilliant people, literally giving up their lives freely, for the good of the others and of the mankind, most common people take their brilliant inventions and theories for granted, rarely appreciating the endeavours of these creative and brilliant people.

Tesla’s main objective, for example, was to provide free energy for the masses but the interests of the oil magnates and tycoon were much greater than this noble goal of this genius scientist. Since he almost did not sleep or he barely slept, he virtually sacrificed almost all his life, like a martyr for the good of mankind.

He had no wife; his only love was a couple of pigeons and their death caused him great suffering. After Tesla’s death, at the age of about ninety, American “intelligence” agencies have taken all his personal documents and his archive with plans or drafts of inventions, for purposes of “national security”.

Another brilliant person, Alan Turing has the merit to have shortened the second world war by almost four years due his invention, the precursor of the modern computer, used to decrypt the messages of the germane machine Enigma, saved the lives of many tens of millions of people.

In return, he has been virtually killed by his British fellow countrymen, by prescribing him appropriate drugs for his “condition”, whereas today, exactly those western people and nations give lessons of good practices in their modern societies, good practices to be strictly followed by the entire mankind, out of reasons of democracy, liberty and sex freedom.

Without the brilliance of A. Turing, the inventor of computer who has cracked with his machine the code of the Germane machine Enigma, these tens of millions of lives have been saved, but this fact did not matter for the British people.

He is the most brilliant British who ever lived and only in 2011, the British tried to” rehabilitate and to pardon him”, when he himself is the one who actually should pardon his entire nation, not the reverse way!

And thus, a pattern is also forming, whereas many of these brilliant, creative and highly intelligent persons were also martyrs and they also died martyred by their own fellow countrymen.

Common people almost always either do not leave anything behind them or they only leave dirt scratched from the lives of others, much more capable than they are.

Ordinary people only meticulously follow the heard with conscientiousness and they disregard the achievements of others as well as the benefits they have from these “crazy” people, nor fitting into their worldview, neither into their success patterns.

Big issues of science and mankind are always solved by these uncommon, weird, freaky and almost always un-understood geniuses, not fitting into the patterns of the common people.

It seems that the law of life evolution in its general understanding, fitting and adapting in order to survive or in order to increase the chances of survival, law which is valid at the level of the vegetal and animal kingdom, not only does not apply to humans, but is really reversed when it is about the survival of great numbers of people or even the survival of human race; the main issues of mankind are not solved by the adapted herds of people



sharing their little passions and interests, more recently on their “asocial” networks, but by these not adapted, peculiar and creative geniuses.

It also seems that the ability to solve complicate issues, exactly like in the case of resilient people, is owned by those who do not conform and who are considered to be impertinent and cheeky persons and at the same time, they are recognized not to think conventionally.

## 5. CAN A.I. BE BRILLIANT?

In the present days, one could argue that it is not necessary anymore to have all this information and knowledge needed to solve the problem, in one’s own brain, since it is effortlessly and freely available by means of the internet and of the artificial intelligence.

This statement is far from truth, since was already explained above that the connections within this knowledge and information are made by the brain of the genius, whose brain, moreover, is additionally modelled while acquiring this information.

Since A.I. can hardly replicate and simulate even most simple basic life intelligence processes, as a concluding and summarizing statement regarding the potential brilliance of A.I., one can say that not only in the present, but also on the medium and long term, A.I. would not be able to achieve the level of normal common intelligence, unless major breakthroughs or discoveries, related to understanding the functioning of human brain are made. Not to mention that it could not have too soon the ability to think like a genius.

In the very same way and manner in which ordinary primitive people seek to denigrate geniuses, the present A.I. can only spy, find and recognize patterns and at most combine more or less valuable information and data, which is already available on internet.

The best which this present day A.I. can do is that it only can steal and recombine valuable information and data, data and information which is or was, however, generated also by the brilliant and creative minds of geniuses.

The present stage of A.I. is not at least the stage of the most primitive life forms on Earth. At its level nowadays’ A.I. and in this stage can only scratch and rummage through huge amounts of data which is generated voluntarily or involuntarily by people interacting with the internet and with their online environments.

A.I. having thus not at least the intelligence of the most primitive life forms and not operating at least at the level of the intelligence of those most primitive organisms, it is far away from the level of normal human intelligence, not to mention how far away it is from the intelligence level of really brilliant people.

Thus, this present level of A.I. is very much the same level of “normal and ordinary” people, scratching dirt and rummaging the trash from the lives of brilliant people, in order to discredit and to denigrate them and to

bring them to their ordinary level, as described and presented above.

Hence, present day A.I. has the same level of sophistication as that of people rummaging the trash in the lives of others.

A brilliant person however, intelligently selects and combine past and present information for his purposes and then employs his creativity and his intellectual skills and abilities to solve the respective problems.

In other words, to put it more gently, it is to be expected that A.I. will be equally brilliant as its human creator, with almost the same chances for man to be equal in its intelligence with his Creator.

Because it is not the information, or the access to data, which make inventions or make discoveries, but it is actually the human mind which makes them. The equivalent of the human mind for the A.I. is the algorithm programmed by humans, which is now, at most, at a primitive stage.

It is very long time, maybe never, until human mind alone will be able to generate something similar in performance with the human mind itself, human mind which is actually God’s Creation.

This may only be possible, in a very unforeseeable future, and only after the convergence or in a partnership between God, humans and A.I., as it presented in the paper [7].

Since God has created this marvellous creation which is the human mind, and if it is that A.I. will be able to ever be equal or even to surpass the human intelligence, this will happen only with the permission and under the supervision of God which is the Creator of the human mind, if He is to have ever, in an unpredictable future, humans as His partners [7].

## 6. CONCLUSIONS

People often tend to think about geniuses that they are people who effortlessly solve complicate problems or who continuously have new brilliant ideas, but nothing can be farther from truth.

Real geniuses, however, who really leave something after them, are indeed brilliant people with extraordinary mental abilities, but they also have the ability to work hard and to make huge efforts and relentlessly persist in order to pursue a certain idea or a certain goal.

One cannot, by all means, be brilliant unless one has previously acquired knowledge out of which to derive new knowledge, like solutions to problems or inventions.

This previously acquired knowledge is a sine qua non condition for all the presented cases before, so the key element to solve a certain problem is to acquire as much as possible from the existent knowledge which is directly or indirectly related to the solving of the respective problem, and only then to be able to use one’s own brain like in the case of the geniuses above.

Brilliant people have the ability to accumulate large amounts of knowledge related to their ideas or to the problems they want to solve, not only in their own field



of study but also in related fields, and this effort to read and know all what is directly or indirectly related to their field of interest, also causes permanently new connections in their brain, fact which thus causes their brain also to permanently evolve and eventually

culminates with the solving of their problem to which they gave thoughts.

The chances that A.I. will possess in the near future the brilliance of the geniuses is virtually zero and infinitely small when regarding the far future.

## 7. REFERENCES

[1] O'Neill, John J., *Prodigal genius: The life of Nikola Tesla*, Kempton, Ill.: Adventures Unlimited Press, 2008. Retrieved via Internet Archive, Identifier: prodigalgeniusli0000onei

[2] Tesla N., *The strange life of Nikola Tesla*, Kolmogorov Smirnov Publishing. Retrieved via Internet Archive, Identifier: NikolaTeslaTheStrangeLifeOfNikolaTesla

[3] Isaacson W., *Einstein: His Life and Universe*, New York, Simon and Schuster, 2007. Retrieved via Internet Archive, Identifier: einsteinhislifeu0000isaa\_o4d0

[4] Hodges A., *Alan Turing: The Enigma*, New York, Simon and Schuster, 1983. Retrieved via Internet Archive, Identifier: alanturing00andr

[5] Calinescu G., *Viata lui Mihai Eminescu*, Publishing House Semne, 2004

[6] Hesse H., *The Steppenwolf* (Original title), Frankfurt am Main, Suhrkamp Verlag, 1996, *Lupul de stepa*, Publishing House Rao, 2015, Bucharest, Romania

[7] Nutu C. S., 2023, *Early Transhumanism Ideas and their Extensions regarding Evolution of Technology and of Artificial Intelligence*, Journal of Maritime Technology and Environment, Vol.1, Year 2023



## EVOLUTIONS IN COMMUNICATION WITH A.I. SYSTEMS OF GENERATIVE PRETRAINED TRANSFORMATIVE TYPE. DEVELOPING A.I. MEDICAL TECHNOLOGIES AND TOOLS BASED ON DATA PREVIOUSLY ACQUIRED BY A.I. E-LEARNING TECHNOLOGY SYSTEMS

NUTU Catalin Silviu <sup>1</sup>

<sup>1</sup>Constanta Maritime University, Faculty of Naval Electro-Mechanics, 104 Mircea cel Batran Street, 900663, Constanta, Romania, e-mail: nutu\_catalin@yahoo.com

**Abstract:** This paper presents how A.I. can be used to create and develop useful applications, but also how data from a certain area of A.I. can be hijacked and repurposed in other areas of A.I, sometimes without the prior consent of the users, or even worse, information can be even hacked and used for evil purposes. It also shows how this fact can jeopardize and infringe upon the rights of users giving up their sensitive personal data in internet.

**Keywords:** eLearning, eLearning A.I. based technologies, A.I. based medical technologies

### 1. INTRODUCTION

The present paper refers extensively to the new applications of the A.I. models of GPT type, explaining the functioning of a fine-tuned instrument to be used individually by people, either as an effective substitute for a teacher or as a psychological adviser.

One of the facts related to A.I. today is that many people really believe that this is already so clever that it is “thinking” and is understanding them. They are also scared about the dangers related to A.I. and consequently they fear this intelligence which is, at the moment, merely only simply spying on them, by gathering “intelligence” about them.

A.I. then can use this information, either to manipulate them to have certain attitudes, or by selling them products, based on their internet searches or their online interests, as presented in [6].

This situation of fear can also cause significant mental stress regarding A.I. because people does not understand that their interaction with A.I. is based on the data they freely, voluntarily and unconsciously gave away in internet, when they interacted with these modern technologies and they do not understand where from is all this information about them, which is used nowadays, mostly, to sell them stuff.

But, however, as it is presented in this paper, in addition to that, there are also some upsides regarding the using of A.I. in the near future, advantages designated either to help people who want to improve their knowledge and skills using A.I., but then again, this advantage can also be hijacked by A.I. and the respective

information gathered may be used in other purposes, as it will be shown in this paper.

This paper presents concretely how data acquired by the advanced A.I. eLearning instruments from their interaction with people, can be further used, sometimes without peoples’ consent, to create A.I. medical technology tools to help people with their various medical needs, but this acquired information could also be used in other, more harmful ways, which will be not further addressed in this paper.

At the first stage, people will more often use A.I. for learning purposes. A.I. will become thus better and better in understanding their interests, their learning needs and skills. But, at the same time, A.I. will thus acquire information, data and details about people interacting with A.I. out of learning purposes, data acquired by means of these eLearning instruments.

### 2. ISSUES IN THE MODERN SOCIETY

Viktor Frankl, a Jewish doctor and survivor of Nazi concentration camps, is the originator of the science of logo therapy. As father of logo therapy, he has already some decades ago intuited the problems of our society, with increasingly alone and lonely people, problems which nowadays became reality, and a lot of these problems have been also caused by technology itself. But, luckily enough, this technology which is the culprit for many mental issues nowadays, can be also used as a tool and a solution to solve such issues.

According to Frankl, questions about the meaning of life cannot be answered with general statements. According to him, “life is not something vague, but



something very real and concrete, in the same way in which the tasks of life are real and concrete. All these make up one's destiny which is different and unique for each individual. No man and no situation can be compared because no situation repeats identically and hence, each individual situation requires a different reply and reaction".

Frankl admits that for more than a half century, psychiatry tried in vain, and in the end failed to interpret the human mind as a mechanism or machinery and the related therapy as a technique. Therefore, he states the necessity for both, psychology and psychiatry to be rehumanized. The human being is not a machine and moreover he has the ability to be self-determined. These thoughts of Frankl, a Jewish who suffered and survived the Nazi extermination camps and who generated those thoughts based on his harsh experience in these Nazi concentration camps, offer the explanation and the motivation behind this paper.

According to psychologists and as also stated in [1], there are mainly three wills: the will of sense (in life), on which the science of logo therapy is based, the will of pleasure, on which the Freudian psychoanalysis theory is based upon, and the will of power, on which the Adlerian psychology theory is based upon.

In accordance with the explanations of Frankl, the science of logo therapy is derived out of the Greek word "logos" which has the meaning of "meaning or sense". This Wiener school of psychology is focusing on the "meaning of human existence" and on the "process of searching of this meaning".

V. Frankl restates the words of Nietzsche and makes them a motivation for the importance of logo therapy: "the one who has a *why*, will endure any *how*"

In modern times, due to various unfortunate factors, evolution of society and evolution of technology, many people are living senseless lives. These problems of modern people and unfavourable evolutions are extensively presented by Frankl in [1].

Frankl explains the loss and the lack of meaning of the modern individual by the concept of "existential void".

He explains that at the dawn of civilization, mankind has lost some of his essential basic instincts due to the fact that humans have to make decisions. Besides that, Frankl explains that the same outcome of existential void and hence lack of meaning has occurred with the loss of ancient traditions and rituals.

That is why, the modern human wants to do what the others do, that is to say he conforms, or he wants to do what the others want, that is to say he is subjected to totalitarianism. This existential void has as an effect the feeling of boredom. According to the data of Frankl, this sentiment of boredom brings more people to the psychiatrist than the feeling of suffering.

Once with the automatization of the industrial processes and today's technologies based on A.I., people will have increasingly more time available and they will also experience more and more this existential void,

because they do not know how to deal with and how to use this available increased free time.

The goal of logo therapy is to fill this existential void and to show the patient under this therapy the meaning of *his particular life*. Because the meaning of life provided by the science of logo therapy is the specific sense of one particular person, but not the meaning of life in general manner.

The "lack of meaning of life" which is caused by this "existential void" leads to serious mental conditions such as depression, anxiety, aggressivity, addictions, drugs abuse and sometimes the lacking will of sense of life is replaced by the will of power, exhibited in the form of greed or money accumulation or it is replaced by the will of pleasure.

Also, according to Frankl, logo therapy considers the responsibility as essence of human existence. Some other authors are regarding the etymology of this word "responsibility" as the ability to give response or to respond to the challenges and issues one encounters in life.

A special kind of this "ability to respond" regards a special ability and quality of some special humans who are endowed with the ability to respond properly to harsh challenges, hardships and hurdles of life, having the advantage and ability to be resilient, as presented in [2].

### 3. HIJACKING AND REPURPOSING DATA GATHERED BY A.I. E-LEARNING INSTRUMENTS TO SOLVE MEDICAL ISSUES

Before the modern era, very much unlike today, the solutions for psychological conditions were found in the community and in its traditions, in family, friends or religious or medical advisers.

Former eLearning instruments, techniques and technologies were developed once with the evolution of the internet and of the software instruments. Until a few years ago, they were based on general data and information about groups of people, obtained by classical marketing segmentation techniques.

Nowadays, once with the development of data mining techniques and of A.I. the eLearning instruments have become more and more sophisticated.

The design of such advanced systems ready to collect data and information about persons accessing them are already described by one of the software giants, Microsoft, such as presented by their originator in [3], [4] and [5].

Such systems, able to collect huge amounts of details and data which will be stored in the servers of the company, are already heavily advertised in education institution and they will be most likely very used by various pupils and students, and these kinds of instruments will also be advertised, most likely in this first stage, as "free" instruments to be accessed.

With the use of these new technologies, some people having either mental issues or wanting to improve their knowledge and skills, could be efficiently and





effectively personally and individually helped to solve their issues, based on the data and information they freely gave about them in internet.

One issue with such an A.I. instrument, created to help those people in need, is that the data and information gathered about anyone, may be acquired without the consent of the user of technology, and hence, may be illegally acquired.

One other issue may regard the accessibility of such data gathered about people, using such A.I. instruments, in the sense that the ones possessing this data may also be use it in other harmful ways.

At its first stage of development, in education, A.I. instruments will be useful because of the tailored experience, customized and personalized depending on the level of intelligence, understanding and previous knowledge of each user.

Subsequently, based on the input data, A.I. will be able to identify unusual ways of thinking of people using the internet. It will be able even to identify either brilliant people or people with lower intelligence levels and it will help them by tailored experiences, according to their intelligence levels.

By analysing the interests, videos watched and online activity in general, A.I. could adopt the best approach to a person and the best way to teach that person. It could be used to train people to learn new things based on the information about them and about all people, information available in internet.

At its second stage, based on the information acquired at the previous first stage of development, A.I. instruments will be then also able to identify potential medical problems in people accessing the internet, based on both: on their internet searches but mostly on their interaction with the A.I. eLearning instruments.

In psychological treatment, this tool will be employed based on the same personalized, customized approach, regarding both, personality and data about the respective patient. Based on data gathered about the potential patient, this A.I. tool should identify and “discern” among the possible existing psychological problems of the respective patient. Taking into account the previous section, once with the occurrence of A.I., this tool can also be used to help people in need, but this tool should use wisely the data it accesses about anyone and should be also more humanized by means of special interactions and interfaces, but also by adopting a friendly and humanized approaches, in the communications with its learning trainee or its patients.

This A.I. communication tool could identify which of the previous categories of will prevails in the respective patient, and then this tool could employ an adequate method to communicate with the patient and to treat one in the most appropriate way.

It will be able to generate different evolution scenarios for communication respectively interaction

activities with its subjects, and it will be also able to correct and adapt these scenarios in real time, according to the evolution and interaction with the subjects, based on both, mined big data in internet and data gathered about each individual.

This tool will also take into account that each individual person is different and so complex, as presented in [2], that former psychological theories fitting individuals into small typology boxes cannot be applied when dealing with psychological patients. It will also be able to treat psychological issues of persons with personal background experiences.

A really good doctor should not put a label to on a patient according to his most often limited knowledge and abilities, but he should really be able to listen, understand and give full therapy support to a patient, in accordance and in the way logo therapy does it.

This is another strength of these A.I. instruments by comparison with the usual medical personnel, and in his book [1], Frankl states explicitly that “Psychotherapy should be rehumanized and its usual nowadays practices changed accordingly”. He also affirms that “persons with existential challenges and or crises, should seek advice and guidance to their families, friends, therapists or religious advisers”, which at his time were the only alternatives available.

In this light, an evolution of this type of A.I. could be effective and adequate for a great deal of students and patients.

The A.I. communication tool presented in this paper could also be used as a substitute for the needs and issues of such individuals. This A.I. tool may have the potential to fill one’s existentialism void, based on experiences of similar persons who found meaning and sense in life. It could also fill the gaps in one’s knowledge by teaching this one using the methods and instruments most suitable for one’s personality.

Due to A.I., many disciplines and fields will be made and may become obsolete by A.I. Using A.I. to replace people in these fields will negatively affect the intelligence of man, because connections in the human mind and the wiring of the human brain will not happen anymore as previously, since human mind will not be used anymore to make these connections. By using A.I. instruments replacing the use of human mind, humanity and mankind will consequently become poorer and poorer in intelligence and the abilities of man to understand facts and things will thus permanently decrease.

Karl Marx was among the first ones to remark in his illustrious work “The Capital” that “humans are not using the means of production, but instead they actually are used by those means of production”. This applies in the very much same way when regarding the use of the nowadays new technologies, where people are

unconsciously “used” and even “consumed” by these technologies.



There are, however, significant advantages regarding the use of these new technologies, which no one could deny, as it is presented in this paper.

Because of the potential dangers related to its use, this type of instrument should be used firstly only under the supervision of a teacher or a psychological doctor, and they should be used as independent and standalone instruments only when the time is right for their use without human supervision.

The A.I. communication tool presented could be used either for personalized psychological treatment or for customized training of certain abilities and learning purposes.

The existence of this A.I. communication tool is based on the assumption that in the near future, A.I. will evolve sufficiently to become a real partner in education and afterwards, based on the acquired data, also a partner in psychological treatment.

#### 4. CONCLUSIONS

The approach in the evolution of communication with A.I. presented in this paper assumes that users themselves or automatically A.I. will set up the level of communication with its users, in accordance with the level of the respective user, so that this A.I. tool will directly speak and teach each of its users according to their actual intellectual capacity and abilities to understand things and issues, thus being able to be more effective than a real teacher or psychological adviser.

This will happen since it will be set up and personally adjusted and personalized fine-tuned for each user, based on the data delivered in internet regarding the respective user and all the other data available in internet. Having been set up personalized and tailored in accordance with the level of its user and corresponding to the intellectual abilities and understanding of the user, this new tool will speak and teach each one individually, based on the data delivered in his online interactions with the internet and all its related devices and apps.

#### 5. REFERENCES

[1] Frankl V., *Men Search for Meaning* (Original title), Copyright 2006, Beacon Press, *Omul in cautarea sensului vietii*, Vellant Publishing House, 2018

[2] Siebert A., *The Resiliency Advantage* (Original title), Copyright 2005, *Avantajul rezilientei*, Business Tech International, 2009

[3] <https://learn.microsoft.com/en-us/training/educator-center/topics/ai-for-education>

The present human population has very segregated levels of intelligence of individuals and most of the users of the new technologies are claiming that they are keeping up with technology and they are mastering these new technologies, when in fact they are only plain and simple users of their gadgets and of therein related apps.

They are also, many times, manipulated users feeding these hungry technologies with all sorts of their individual and sometimes sensitive personal data and information, thus permanently enriching the big data already stored for long time now. This big data is at the free and permanent disposal of IT giants, giants which already know enough about most of their users with respect to their intellectual level, interests, etc,

These IT giants have nowadays various and huge data mining potential with respect to the big data stored, data which can be used in very many ways.

This new A.I. communication tool will have major applications in both, education and afterwards in psychological treatment.

As it is presented in this paper, A.I. could hijack information gathered from one certain area, repurposing and reusing it later in other completely different areas, without the prior consent of users.

Based on input data regarding A.I. eLearning tools, information gathered at the first stage, at the second stage, A.I. could use this information gathered at the first stage to help people to fight their stress and their anxiety or other mental conditions.

But this help will be made with the cost of the personal data the people sometimes freely, unconsciously and willingly gave up in internet, many times not knowing how this information will be used.

That is why, one should always assess the utility and cost benefit ratio, when giving up its sensitive personal information in internet.

[4] <https://educationblog.microsoft.com/en-us/category/audience/ai-in-education>

[5] <https://educationblog.microsoft.com/en-us/2024/01/unlocking-productivity-and-personalizing-learning-with-ai>

[6] Nutu C.S., 2023, *Early Transhumanism Ideas and their Extensions regarding Evolution of Technology and of Artificial Intelligence*, Journal of Maritime Technology and Environment, Vol.1, Year 2023



## CROWD PSYCHOLOGY AND PUBLIC ORDER EVENT MANAGEMENT: ANALYSIS OF COLLECTIVE BEHAVIOUR AND EFFECTIVE INTERVENTION STRATEGIES

PETRICA Alexandru-Valentin <sup>1</sup>

<sup>1</sup>"Alexandru Ioan Cuza" Police Academy, Bucharest, Police Faculty, Gendarmerie specializations, 1-3 Privighetorilor Alley, 014031 Bucharest, Romania, email: alex.petricaaa@gmail.com

**Abstract:** The management of public order events is a complex task that requires a deep understanding of crowd psychology and effective intervention strategies. This paper provides an analysis of collective behaviour and the key factors that can influence the behaviour of crowds during public order events. It also explores the role of law enforcement agencies and other public authorities in managing public order events and the importance of effective communication strategies. The paper emphasizes the need for a multi-disciplinary approach that incorporates insights from psychology, sociology, and other social sciences in the development of effective strategies for public order management. It argues that a better understanding of the dynamics of collective behaviour can help law enforcement officers to prevent or manage potentially dangerous situations during public order events. Effective communication is another key aspect of public order management, and the paper highlights the importance of clear and respectful language in establishing a rapport with the crowd and reducing the risk of confrontations. It also emphasizes the need for cultural sensitivity in communication strategies, especially in multicultural societies where different groups may have different norms and values. Overall, the paper concludes that effective public order management requires a deep understanding of the psychology of crowds, effective communication strategies, and a multi-disciplinary approach that incorporates insights from various social sciences..

**Key words:** management, public order, crowd psychology, behaviour.

### 1. INTRODUCTION

Crowd psychology is a branch of social psychology that focuses on the study of the behaviour and psychology of individuals within a group or crowd. The term "crowd" refers to a group of people who are together in the same place and time and who can be influenced by the emotions and behaviours of others in the group.

Crowd psychology analyses how group members are influenced by social pressure, factors such as anonymity, and the behaviour of leaders.

This discipline focuses on how people change their behaviour and thinking depending on the group they are in, and can thus help to understand social phenomena such as mass wars, protests, and riots.

Crowd psychology is important not only for understanding collective behaviour in emergency situations, but also for helping to develop communication and leadership strategies that encourage positive and responsible behaviour within groups and communities.

Regarding the management of public order events, it involves planning and implementing security and intervention measures in case of emergency situations

such as protests or public demonstrations. In this context, it is important for authorities to understand collective behaviour and develop effective intervention strategies to maintain public order and minimize risks for participants and other citizens.

Collective behaviour analysis focuses on the study of how individuals behave in a group or crowd.

This may include analysing how people influence each other, how their behaviour changes based on the emotions of others in the group, and how leaders influence the behaviour of others.

Effective intervention strategies are based on these analyses and aim to manage collective behaviour in a way that minimizes risks and maintains public order.

These strategies can include negotiation tactics, tension de-escalation strategies, crowd dispersal, and use of force intervention when necessary.

It is important for these strategies to be applied with discernment and to take into account the specific context of the public order event in question, in order to achieve desired results and avoid escalation of violence or conflict.



## 2. CROWD PSYCHOLOGY

A crowd is a collection or grouping of people who are in the same place and can be influenced by the behaviour and emotions of others in the group. Crowds can be organized or spontaneous and can be composed of a variable number of people. Additionally, crowds can be formed in diverse contexts such as sporting events, concerts, protests or other public gatherings. The behaviour of crowds can be influenced by various factors such as social, cultural, psychological, and emotional factors, and can vary depending on the specific context of the gathering and the nature of the event.

The characteristics of a crowd can vary depending on the specific context of the gathering and the nature of the event. However, there are some common traits of a crowd, such as:

*Anonymity:* Crowd members may be anonymous or not individually identified.

*Conformity:* Crowd members tend to adopt similar behaviours and follow the actions of other group members.

*Cohesion:* The crowd may be cohesive and united, especially when its members share a common cause.

*Limited communication:* Communication within the crowd may be limited to signs, gestures, and other nonverbal forms of communication.

*Strong emotions:* Crowd members may experience strong emotions, such as anger, enthusiasm, or fear, that can influence their behaviour.

*Rapid reactions:* The crowd can react quickly to external stimuli, such as sounds or movements, and can adopt collective behaviours in real-time.

*Potential for violence:* In some situations, the crowd may become violent, causing material and/or physical damage.

These characteristics can be influenced by different factors, such as the size of the crowd, the context of the event, the nature of the cause, the presence of leaders or authorities, and other social and cultural factors.

### 2.1. Individual behaviour versus collective behaviour

Individual behaviour refers to the actions and reactions of a single individual, independent of other members of the group or community. Individual behaviour can be influenced by internal factors such as personality, past experiences, motives, and emotions, as well as external factors such as social environment, culture, and community values. Additionally, individual behaviour can be affected by the social context and the nature of interaction with other individuals within a group or community.

Collective behaviour, on the other hand, refers to the actions and reactions of a group or community of people who are interacting with each other. [1] It is characterized by a shared sense of identity and a common goal or purpose, which can lead to coordinated

actions or emotional responses. Collective behaviour can take many forms, such as protests, riots, social movements, or crowd events, and can be influenced by various internal and external factors, such as group norms, social influence, and situational factors. The study of collective behaviour is an interdisciplinary field that draws on theories and methods from sociology, psychology, anthropology, and communication studies, among others. Understanding collective behaviour is important for analysing social phenomena and for developing effective strategies for managing and responding to collective events. In contrast to individual behaviour, collective behaviour is often characterized by a sense of anonymity, reduced personal responsibility, and a greater susceptibility to influence by external factors such as group norms, crowd psychology, and the behaviour of other members in the group.

## 3. EXPLANATORY THEORIES AND MODELS OF CROWD BEHAVIOR

### 3.1 Social emergence theory

Social emergence theory is a theoretical framework used to explain collective behaviour in social groups or crowds. According to this theory, the collective behaviour of a group emerges from the interaction and communication between individuals in the group. [2] The behaviour of the group as a whole cannot be predicted or reduced to the behaviour of its individual members. Social emergence theory suggests that the collective behaviour of a group is the result of complex interactions between individuals, rather than the sum of their individual actions. This theory is often used to explain the behaviour of crowds, mobs, and social movements.

### 3.2 Social Identity Theory

Social Identity Theory (SIT) is a theory in social psychology that explains how individuals develop and maintain their social identities within groups. [3] This theory was developed in the 1970s by researchers Henri Tajfel and John Turner. According to the Social Identity Theory, individuals form their social identities by associating themselves with groups they feel connected to and by comparing themselves to other groups. This process of identification with a group can have several consequences, such as a sense of belonging, improved self-esteem, and the adoption of group values and behaviours. At the same time, this identification can also lead to greater discrimination towards other groups and increased rivalry between groups. The Social Identity Theory is relevant in the study of collective behaviour because it explains why people join groups and engage in common actions. Additionally, this theory can help understand the motivations and dynamics of protests and



other public gatherings related to social identity and the fight for rights and social justice.

### 3.3 *The Dynamic Interaction Model*

The Dynamic Interaction Model is a theoretical model that explains how members of a crowd change their behaviour during a collective event, such as a gathering or demonstration.[4]

The model focuses on the interaction between individuals and how this interaction affects collective behaviour. According to this model, collective behaviour is not only determined by individual

## 4. THE MANAGEMENT OF PUBLIC ORDER EVENTS

Managing public order events refers to the actions and strategies adopted by public authorities, such as the police and gendarmerie, to prevent and manage situations that could lead to disturbances of public order or violations of the law during public gatherings or other public events.[5] These events can be diverse, such as protests, political rallies, major sports events or concerts, and their management can be complicated and difficult, as both the civil rights and freedoms of citizens and the need to maintain public order and safety must be taken into account. The importance of managing public order events lies in the fact that they can have a significant impact on society and can affect the lives and property of citizens. Additionally, an event that is not properly managed can lead to property damage and loss of trust in public authorities. Therefore, it is important for public authorities to develop adequate strategies to prevent and manage crisis situations during public order events.

The process of managing public order events involves several stages, which may vary depending on the specific event and the authorities involved. Generally, these stages include:

- a) *Planning* - this stage involves risk assessment and the development of an action plan to prevent or manage any crisis situations.
- b) *Mobilization* - the public authorities responsible for managing the event mobilize the necessary forces to ensure public safety.
- c) *Surveillance and monitoring* - public authorities monitor the event to identify potential risk situations and to intervene promptly in case of incidents.
- d) *Communication* - communication with event participants is important to provide relevant information, make them aware of behavioural rules, and convey safety messages.
- e) *Intervention* - in case of risk situations, public authorities intervene to restore order and ensure public safety.
- f) *Evaluation* - after the event, public authorities carry out an evaluation to identify any issues that arose

behaviour but also by the interaction and communication between members of the crowd. This can lead to the emergence of collective phenomena, such as group polarization or a change in the direction of the crowd's action. The Dynamic Interaction Model is relevant in the study of collective behaviour because it helps to understand the dynamics and evolution of collective actions. It can also be useful in developing strategies for managing crowds and preventing situations of conflict or violence in public gatherings.

and to improve strategies for managing future public order events.

### 4.1 *Strategies and tactics used in managing public order events*

Strategies and tactics used in managing public order events can vary depending on the specific event, location, and context. Some commonly used strategies and tactics include: [6]

1. *Risk assessment and planning*: Before an event, public authorities assess potential risks and develop a plan of action to prevent or manage any crisis situations that may arise.
2. *Communication and engagement*: Effective communication with event organizers and participants is important to ensure a clear understanding of expectations and behaviour. Engaging with community leaders and groups can also help to build trust and promote cooperation.
3. *Crowd management*: Strategies for managing crowds may include creating barriers or cordons to control the movement of people, using crowd control techniques such as crowd psychology and communication, and employing trained personnel such as stewards or marshals.
4. *Use of force*: In situations where public safety is threatened, law enforcement agencies may use force to restore order. However, the use of force must be proportionate and necessary, and comply with legal and ethical standards.
5. *Arrest and detention*: If criminal activity is detected, police may make arrests and detain individuals suspected of committing offences. Procedures for arrest and detention must follow legal requirements and respect individual rights.

## 5. THE ROLE OF PSYCHOLOGY IN MANAGING PUBLIC ORDER EVENTS

Psychology plays an important role in the management of public order events, as it can provide insights into the behaviour of individuals and crowds and inform the development of effective strategies and



tactics for maintaining public order and safety.[7] One aspect of psychology that is particularly relevant to public order management is crowd psychology. Understanding how crowds behave, what factors can influence their behaviour, and how to prevent or manage potentially dangerous situations is essential for effective public order management. Psychology can also inform the development of communication strategies that are effective in calming tensions and preventing violence during public order events. For example, using language that is clear, calm, and respectful can help to establish a rapport with the crowd and reduce the risk of confrontations. In addition, psychology can play a role in the training of law enforcement officers and other public authorities responsible for managing public order events. By providing training on topics such as conflict resolution, de-escalation techniques, and cultural sensitivity, law enforcement officers can be better equipped to manage potentially volatile situations during public order events

## 6. CONCLUSIONS

In conclusion, effective management of public order events requires an understanding of crowd psychology and collective behaviour. Crowd psychology research can inform the development of effective intervention strategies that prioritize de-escalation and non-violent communication. Effective communication is essential in calming tensions and preventing violent outbreaks during public order events. It is important to establish a rapport with the crowd and use language that is clear, calm, and respectful to reduce the risk of confrontations. Law enforcement officers and other public authorities responsible for managing public order events can benefit from training on topics such as conflict resolution, de-escalation techniques, and cultural sensitivity. By providing such training, law enforcement officers can be better equipped to manage potentially volatile situations during public order events. Overall, a better understanding of crowd psychology and collective behaviour can lead to the development of effective intervention strategies that maintain public order and safety while respecting the rights and dignity of individuals and groups involved in the event.

## 7. REFERENCES

- [1] Catalin ZAMFIR, Lazar VLASCEANU, 1998, *Dictionary of Sociology*, Babei Publishing House, Bucharest, pp 121, ROMANIA.
- [2] David MYERS, 2013, *Social Psychology*, 11th edition, McGraw-Hill Education, pp 308-311.
- [3] Marilyn B. BREWER, Miles HEWSTONE, 2004, *Social Identity: Context, Commitment*, Content published by Blackwell Publishers, Oxford, Cap.II, pp 3.
- [4] Susan T. FISKE și Daniel T. GILBERT, 2010, *Handbook of Social Psychology*, John Wiley & Sons.
- [5] Simon HOLDAWAY, 1991, *Public Order and Private Lives: The Politics of Law and Order*, Oxford University Press.
- [6] Peter JOYCE, 2016, *The book Policing Public Order: Theory and Practice*, chapter 7.
- [7] Clifford STOTT, Steve REICHER, 2013, *Crowd Psychology and Public Order Policing: Policing and Society*, published in 2013, chapter 3.
- [8] Mirela-Iuliana SUNDRI 1, Feiza MEMET, 2021, *Tools to engage youth in environmental issues during COVID-19 pandemic*, *CONSTANTA MARITIME UNIVERSITY APPROACH*, Journal of Marine Technology and Environment, issue 1, pp 33-37, Nautica Publishing House, Constanta, ROMANIA.



## URBAN DEVELOPMENT AND ENVIRONMENTAL IMPACT IN THE METROPOLITAN AREA OF CONSTANTA

RAFTU Nicolae<sup>1</sup>, SIRBU Simona Ana<sup>2</sup>, SIRBU Anca<sup>3</sup>

<sup>1</sup>Constanta Maritime University, Faculty of Naval Electromechanics, Environmental Engineering and Protection in Industry, 104 Mircea cel Batran Street, 900663, Constanta, Romania, email: nikyraftu@yahoo.com

<sup>2</sup>National University of Science and Technology POLITEHNICA of Bucharest, 313 Splaiul Independenței, 060042, Bucharest, Romania, email: simona\_ana6@yahoo.com

<sup>3</sup>Constanta Maritime University, Faculty of Navigation, 104 Mircea cel Batran Street, 900663, Constanta, Romania, anca.sirbu@cmu-edu.eu

**Abstract:** The purpose of this article is to draw attention to a potential environmental effect of the Constanta Metropolitan Area's growth. In order to accomplish this goal, the proposed objectives were as follows: measuring the concentration of several environmental variables in three different locations in the Constanta Metropolitan Area as well as assessing the air quality; comparing the measurement results with the hourly records of pollutant concentrations in various locations within the area of interest; and assessing the impact of human activity on the environment. In order to conduct this research, measurements were made with an Air Quality Monitor model JSM-131 and data recorded and provided by the National Air Quality Network and uRad Monitor on hourly concentrations of some environmental parameters in the area of interest were used. Metropolitan areas, which are defined by dense populations and activity centres, can preserve environmental quality by implementing local policies that are tailored to the specific demands of the community. This necessitates identifying and continually maintaining monitoring on local environmental hazards.

**Key words:** air quality, Constanta Metropolitan area, environmental impact, urban development.

### 1. INTRODUCTION

We are living in a period marked by globalisation, increasing inequality and worsening environmental problems. Sustainable Development is the way forward. A solution for the sustainable development of Romania is represented by metropolitan areas, a concept regulated in Romania by law no. 351 of 6<sup>th</sup> July 2001 as “an area established by association, on the basis of voluntary partnership, between the major urban centres (the Romanian capital and the first-tier municipalities) and the urban and rural localities located in the immediate area, at distances of up to 30 km, between which cooperation relations have developed on multiple levels”.

It is now essential that the strategic development perspective goes beyond the geographical or administrative boundaries of the city and goes beyond the metropolitan area itself, in certain functional areas. Development must be understood on a much wider territory, in which there are organic links, economic or otherwise. [1] In metropolitan areas, decisions can be taken at local level that contribute to sustainable development in which preserving the quality of the environment is a primary objective.

This article aims to highlight a probable impact on the environment as a result of the development of the

Constanta Metropolitan Area. In order to achieve this aim, the proposed objectives were to measure the concentration of several environmental parameters in three locations of the Constanta Metropolitan Area and to assess the air quality; to compare the results of the measurements with the hourly records of pollutant concentrations in different points of the area of interest; to assess the anthropic influence on the environmental quality.

In order to conduct this research, measurements were made with an Air Quality Monitor model JSM-131 and data recorded and provided by the National Air Quality Network and uRad Monitor on hourly concentrations of some environmental parameters in the area of interest were used.

### 2. SUSTAINABLE URBAN DEVELOPMENT STRATEGIES AND THE SMART CITY CONCEPT

The European Union (EU) has presented a comprehensive discourse on cities and their development in recent decades. Since the late 1990s, regular meetings between ministers responsible for urban development have led to the consolidation of an “EU perspective” on the urban problem which can be translated into an EU approach to sustainable urban development. This approach has been refined over the years as it has been



implemented on the ground, thanks to the urban initiatives promoted by the EU under its cohesion policy and in the form of other initiatives specifically targeted at the urban dimension. [2]

Emerging and long-standing issues related to urban development (e.g. urban regeneration, urban and regional planning, shrinking cities, urban sustainability, attracting investment, urban marketing, social segregation) require the development of a strategic framework and a revolution in traditional approaches to urban policy and planning.

Sustainable Urban Development (SUD), promoted under EU cohesion policy, consistently underlines the importance of a strategic framework. A key requirement for successful European Regional Development Fund (ERDF) interventions is to ensure that individual investments are part of a long-term strategy with a strong innovative component. To effectively improve city development trajectories, strategic planning requires collective planning processes and tailored and realistic visions. [3]

### 2.1 Metropolitan development in Romania

The process of growth of metropolitan areas reflects the history of urbanisation processes. Industrial and technological development, forms of transport, have crucially influenced the process of development or annexation of territories around urban centres.

The implementation of metropolitan development policies shall be in line with Romania's overall development objectives and priorities, as well as with the objectives in the field of urban and regional development and economic and social cohesion assumed by Romania as a member state of the European Union. Metropolitan development policy shall be based on the principles of local autonomy, cooperation and partnership.

Evidence shows that Romania's metropolitan areas are vital for the country's economic growth and that population fluctuations in these areas need to be closely monitored and addressed by the authorities to ensure sustainable and balanced development across the country.

### 2.2 General analysis of air quality in Constanta Metropolitan Area

Constanta Metropolitan Area is the first administrative structure of its kind in Romania that fits the EU administrative model, established in 2007 and includes, in addition to the municipality of Constanta (first rank municipality of national importance with potential influence at European level, the most important city in the South-East Development Region), a number of urban and rural localities located in the immediate area, within a radius of about 35 km.

The establishment of the association has opened the door to permanent cooperation between the localities that make up the metropolitan area and has created the

possibility of joint implementation of projects of regional interest, using existing funds from the 2007-2013 financial year, thus contributing to reducing the existing disparities between urban and rural areas by improving living conditions and creating new jobs.

For the assessment of air pollution in Constanta, 3 automatic air quality monitoring stations have been installed (Culture House area; City Hall Park area; Prelungirea Liliacului street no. 6), as well as two other stations in Năvodari (Victoria Camp; Lazăr Edeleanu High School), which provide the public and decision makers with data and information with a degree of certainty.

The stations are equipped with analysers for sulphur dioxide, nitrogen dioxide and oxides; carbon monoxide; ozone; particulate matter (PM 10, PM 2.5.); benzene; VOCs (volatile organic compounds) and transmit results in real time. Measurements are carried out continuously and an hourly average for each quality indicator is integrated from the values obtained, which can be compared with the maximum permissible value for that range (as required by the European Union).

The monitored pollutants are those provided for in the Romanian legislation, transposed from the European one, the limit values imposed by Law 104/2011 (Law on the quality of the environment) aiming to avoid, prevent and reduce harmful effects on human health and the environment.

These pollutants have an acidifying effect on the environment due to the presence of halogen compounds that cause a series of chemical reactions in the atmosphere, leading to changes in the pH of the air, precipitation and soil.

Acid deposits affect surface water, groundwater and soil, with significant damage to lakes and fish life, forests, agriculture and animals.

Dust pollution of the atmosphere can have natural sources, such as the entrainment of particles from the ground surface by wind, or anthropogenic sources: production processes (metallurgical industry, chemical industry, etc.), energy sector burns, construction sites and road transport, industrial and municipal landfills and dumps, individual heating systems, especially those using solid fuels, etc.

For sedimentable particulate matter (PM 10; PM 2.5) exceedances are relatively frequent, caused both by pollution from traffic, industrial activities and the operation of bulk commodities, as well as desertification trends in the area.

## 3. THE METROPOLITAN AREA OF CONSTANTA AND THE ENVIRONMENTAL IMPACT OF THE URBAN DEVELOPMENT

The Constanta metropolitan area has experienced intense development in recent years. For the assessment of the impact of anthropogenic activities on the quality of the environment, 3 points of the metropolitan area were chosen: CET (Thermal Energy Complex)



Constanta (44.15703°N, 28.60974°E), Năvodari, near Midia platform (44.32857°N, 28.64110°E) and Ovidiu Waterfront Park (44.25576°N, 28.57348°E). CET Constanta and Midia Platform represent two of the areas with the highest risk for air quality in Constanta municipality; Ovidiu Waterfront Park was chosen to highlight the possible influence of transport on air quality in an area considered to be a relaxing place for the population.

In these locations, from February to May 2023, 7 sets of measurements of concentrations of total volatile organic compounds (TVOC), formaldehyde, particulate matter with a diameter of 2.5 and 10  $\mu\text{m}$  (PM2.5 and PM10 respectively) and carbon dioxide were carried out. Measurements were made with an Air Quality Detector model JSM-131. The results of the measurements were then compared with those provided by the Environmental Protection Agency following air quality monitoring in stations CT1 - Constanta Culture House area, CT2 - Constanta City Hall Park area and CT3 - Năvodari area.

### 3.1 Variation in concentration of total volatile organic compounds

The concentration of volatile organic compounds (TVOC) recorded a minimum on 5 May of 0.022  $\text{mg}/\text{m}^3$  at CET Constanta station and a maximum of 1.589  $\text{mg}/\text{m}^3$  at Midia-Năvodari station on the same day. On average, the highest TVOC concentration was calculated at Midia - Năvodari with a value of 0.78  $\text{mg}/\text{m}^3$ , followed by Ovidiu Waterfront with a value of 0.7  $\text{mg}/\text{m}^3$ , at CET the average value recorded for this parameter was 0.43  $\text{mg}/\text{m}^3$ , representing 54% of the average calculated at Năvodari (Table 1).

Table 1. Statistical parameters of volatile organic compounds concentration [ $\text{mg}/\text{m}^3$ ]

	CET Constanta	Năvodari - Midia	Ovidiu Waterfront
Maximum	1.292	1.589	1.429
Minimum	0.022	0.064	0.434
Average	0.430	0.785	0.700

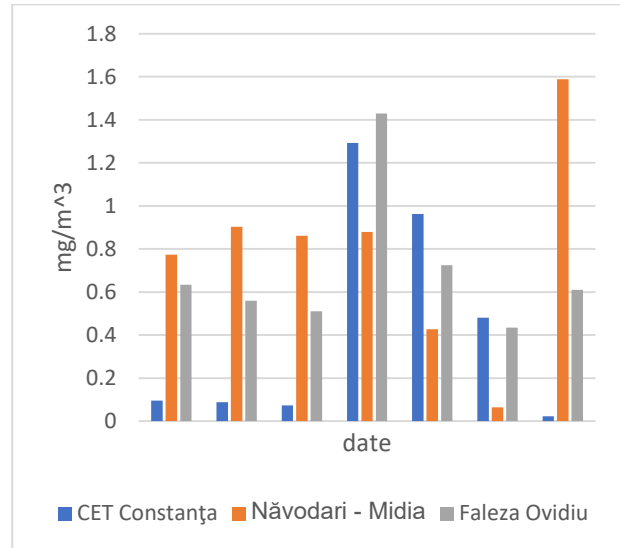


Figure 1 Variation in concentration of volatile organic compounds [ $\text{mg}/\text{m}^3$ ]

In four out of the seven sets of measurements the TVOC values were higher at Midia-Năvodari station. (Figure 1).

### 3.2 Variation in formaldehyde concentration

Among the volatile organic compounds an important role is played by formaldehyde; it showed concentrations ranging from 0.004  $\text{mg}/\text{m}^3$  on 5<sup>th</sup> May to 0.67  $\text{mg}/\text{m}^3$  on 28<sup>th</sup> April, both values being recorded near CET Constanta. The authors calculated an average formaldehyde concentration of 0.1  $\text{mg}/\text{m}^3$  at the Ovidiu station, 0.11  $\text{mg}/\text{m}^3$  at Năvodari and 0.18  $\text{mg}/\text{m}^3$  at CET Constanta (Table 2).

Table 2. Statistical parameters of formaldehyde concentration [ $\text{mg}/\text{m}^3$ ]

	CET Constanta	Năvodari - Midia	Ovidiu Waterfront
Maximum	0.67	0.228	0.196
Minimum	0.004	0.01	0.054
Average	0.182	0.117	0.101

In four out of the seven sets of measurements, the levels of formaldehyde were higher at the CET station in Constanta. Similar plots of TVOC and formaldehyde values are observed for 11<sup>th</sup> and 26<sup>th</sup> March, as well as for 5<sup>th</sup> May, indicating that formaldehyde is one of the main components of TVOC (Figure 2).

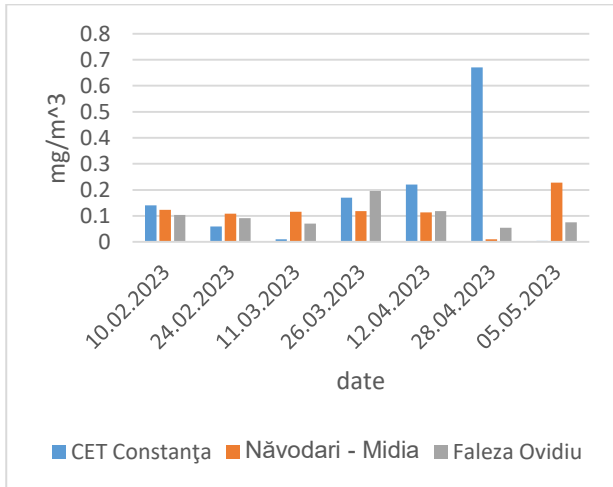


Figure 2 Variation in formaldehyde concentration [mg/m<sup>3</sup>]

Values greater than 0.06 mg/m<sup>3</sup> recorded for formaldehyde exceed the odour detection threshold, those greater than 0.01 mg/m<sup>3</sup> exceed the eye irritation threshold and those greater than 0.1 mg/m<sup>3</sup> exceed the throat irritation threshold. Only the reading on 5<sup>th</sup> May 2023 at CET Constanta was lower than the threshold values mentioned above.

The highest average values of formaldehyde and TVOC were not found at the same air quality monitoring point, which allows us to assess that there is no permanent, point source of emission of volatile organic compounds.

### 3.3 Variation in carbon dioxide concentration

The CO<sub>2</sub> concentration ranged from 755 ppm recorded at CET Constanta on 5<sup>th</sup> May 2023 to 1894 ppm on 24<sup>th</sup> February 2023 also at CET. On average, the CO<sub>2</sub> values were 1185.43 ppm at CET Constanta, 1068.86 ppm near the Midia - Năvodari platform and 1036.57 ppm on the Ovidiu Waterfront (Table 3). The average CO<sub>2</sub> concentration values measured at Ovidiu Waterfront represent 87% of the average of the measurements made at CET Constanta.

In six out of the seven sets of measurements the CO<sub>2</sub> values were higher at the CET Constanta station (Figure 3).

Table 3. Statistical parameters of CO<sub>2</sub> concentration [ppm]

	CET Constanța	Năvodari - Midia	Ovidiu Waterfront
Maximum	1894	1220	1179
Minimum	755	788	836
Average	1185.43	1068.86	1036.57

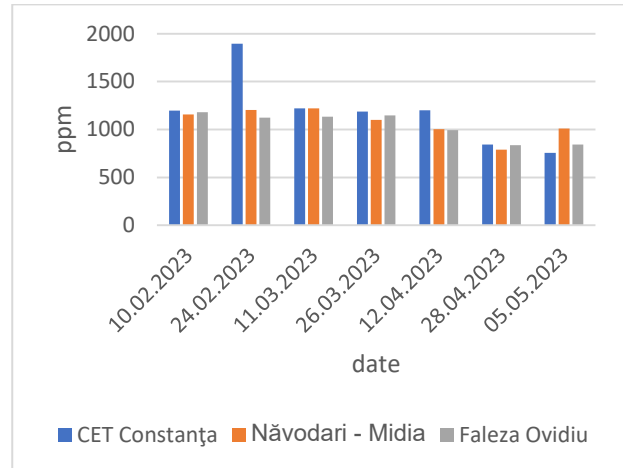


Figure 3 Variation in CO<sub>2</sub> concentration [ppm]

The results obtained, with the highest average value in the CET area, are plausible given that the measurements were taken at the time of year when heating was being supplied to the population. From the graphical representation it can be seen that emissions decreased in the second half of April and in the sets of measurements in May. It should be noted, however, that the CET values slightly exceed the measured CO<sub>2</sub> values at the other two locations and that the May results show a higher concentration in the Midia Platform area. According to the CO<sub>2</sub> concentration ranges and air quality classification, none of the measurements has a value belonging to the “very good” quality class (< 450 ppm CO<sub>2</sub>); 6 out of 21 measurements classify the air in the “good” quality class, with CO<sub>2</sub> between 451 and 1000 ppm; 14 measurements classify the air in the “slightly polluted” range, with CO<sub>2</sub> concentrations between 1001 and 1500 ppm and one measurement shows the CO<sub>2</sub> concentration value for the polluted category (1894 ppm CO<sub>2</sub> at CET).

### 3.4 Variation in the PM<sub>2.5</sub> concentration

The values for PM<sub>2.5</sub> showed a minimum of 3 μg/m<sup>3</sup>, recorded at all three stations on 28<sup>th</sup> April and 5<sup>th</sup> May, and on 26<sup>th</sup> March at CET and Midia. The highest value recorded from the measurements was 17 μg/m<sup>3</sup> on 11<sup>th</sup> March at Ovidiu Waterfront.

The averages at the 3 locations ranged from 6 μg/m<sup>3</sup> at Midia to 7.71 μg/m<sup>3</sup> at Ovidiu Waterfront (the average at Midia is 87% of that calculated at Ovidiu Waterfront) (Table 4).

There is a decrease of less than half of the PM<sub>2.5</sub> concentration in the last 4 sets of measurements compared to the first measurements in February and the first half of March for each station (Figure 4).

Table 4. Statistical parameters of PM2.5 concentration [ $\mu\text{g}/\text{m}^3$ ]

	CET Constanța	Năvodari - Midia	Ovidiu Waterfront
Maximum	13	10	17
Minimum	3	3	3
Average	7.14	6	7.71

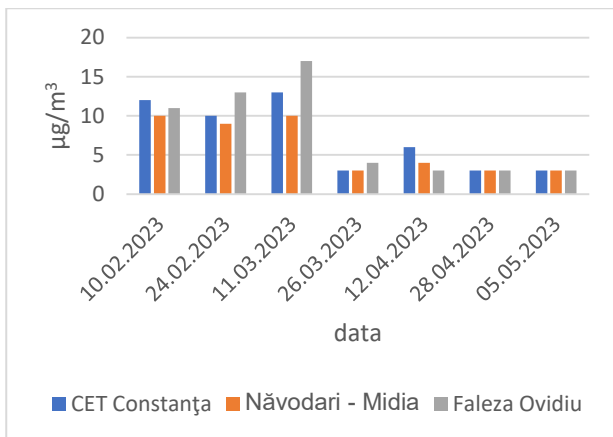


Figure 4 Variation in PM2.5 concentration [ $\mu\text{g}/\text{m}^3$ ]

Of the values recorded with the PM2.5 portable monitor, 38% fall into the “acceptable” category, specific quality index 2, the remaining 62% into the good category, specific quality index 1 (Table 5).

The values recorded on site were compared with those provided by the air quality sensor on Aleea Nalbei, Constanța, (uRad Monitor). Thus, for 10<sup>th</sup> February the value recorded near CET of 12  $\mu\text{g}/\text{m}^3$  is close to the daily minimum recorded on Aleea Nalbei of 11  $\mu\text{g}/\text{m}^3$ ; on 24<sup>th</sup> February and 11<sup>th</sup> March, the values recorded with the portable monitor are higher than the values for q3 (9  $\mu\text{g}/\text{m}^3$ ) on Aleea Nalbei; on 26<sup>th</sup> March the value measured at CET is lower than the average values on Aleea Nalbei. For the rest of the measurements at CET the values are close to the average value recorded on those days. The highest value recorded by uRad Monitor was 39  $\mu\text{g}/\text{m}^3$  on 10<sup>th</sup> February (Table 6). The values recorded by this sensor place the air quality in the quality class “bad” for 10<sup>th</sup> February 2023, “moderate” for 24<sup>th</sup> February 2023 and 26<sup>th</sup> March 2023, “acceptable” for 11<sup>th</sup> March 2023 and 12<sup>th</sup> April 2023, “good” for 28<sup>th</sup> April 2023 and 5<sup>th</sup> May 2023.

Table 5. Variation of the air quality index for PM2.5

	CET Constanța	Năvodari - Midia	Ovidiu Waterfront
10.02.2023	2	2	2
24.02.2023	2	1	2

11.03.2023	2	2	2
26.03.2023	1	1	1
12.04.2023	1	1	1
28.04.2023	1	1	1
05.05.2023	1	1	1

Table 6 PM2.5 variations recorded by the sensor on Aleea Nalbei, Constanța

	Min	Max	q1	q2	q3
10.02.2023	11	39	25	29	32
24.02.2023	2	21	4	7	9
11.03.2023	1	18	4	6	12
26.03.2023	0	21	1	5	10
12.04.2023	0	20	1	2	8
28.04.2023	0	9	1	2	3
05.05.2023	0	9	1	3	5

It is worth noting that the Environmental Protection Agency’s sensors in Constanța did not provide data for PM2.5 on those days.

### 3.5 Variation in the PM10 concentration

PM10 values ranged from 3  $\mu\text{g}/\text{m}^3$  at CET Constanța on 5<sup>th</sup> May to 30  $\mu\text{g}/\text{m}^3$  on 11<sup>th</sup> March on the Ovidiu waterfront. The average values recorded in the 7 days of measurements were 12.14  $\mu\text{g}/\text{m}^3$  at CET, 9.71  $\mu\text{g}/\text{m}^3$  at Midia and 14.57  $\mu\text{g}/\text{m}^3$  on Ovidiu Cliff (Table 3.7). The average value at Midia Năvodari represents 66.67% of the average value calculated for the Ovidiu Waterfront point.

It is noted that the values recorded in the first 3 sets of measurements are 3 to 6 times higher than the values in the last 4 sets of measurements. The graphs are generally similar in the 7 sets of measurements (Figure 5).

Table 7. Statistical parameters of PM10 concentration [ $\mu\text{g}/\text{m}^3$ ]

	CET Constanța	Năvodari - Midia	Ovidiu Waterfront
Maximum	24	19	30
Minimum	3	4	5
Average	12.14	9.71	14.57

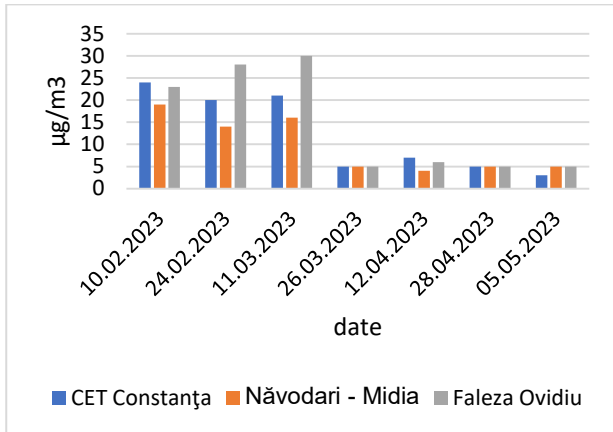


Figure 5. PM10 concentration in the measurement sets [µg/m³]

Table 8. Variation of the air quality index for PM10

	CET Constanța	Năvodari - Midia	Ovidiu Waterfront
10.02.2023	2	1	2
24.02.2023	2	1	2
11.03.2023	2	1	2
26.03.2023	1	1	1
12.04.2023	1	1	1
28.04.2023	1	1	1
05.05.2023	1	1	1

Of the values recorded with the handheld device for PM10, 71.4% fall into the “good” category, specific quality index 1, the remaining 28.6% into the “acceptable” category, specific quality index 2 (Table 8).

The measured values were compared with the hourly values provided by the Environmental Protection Agency from the air monitoring stations CT1 (Culture House Area) and CT2 (City Hall Park) in the city of Constanta and CT3 (Mamaia Nord - Midia) in Năvodari.

On 10<sup>th</sup> February 2023, the PM10 value measured with the air quality detector model JSM-131 at CET Constanta, 24 µg/m<sup>3</sup> was between the values recorded by the sensors of the Environmental Protection Agency - APM Constanta, which at the same time showed values of 28.14 µg/m<sup>3</sup> at the House of Culture (CT1) and 14 µg/m<sup>3</sup> at the Town Hall (CT2). The APM CT3 station in Năvodari recorded a value of 28,14 µg/m<sup>3</sup>, while in Năvodari we measured 19 µg/m<sup>3</sup> and in Ovidiu 23 µg/m<sup>3</sup> (Figure 6) For the date of 10<sup>th</sup> February.2023 the hourly averages recorded by the APM sensors classify the air quality as “very bad” due to the values at CT1.

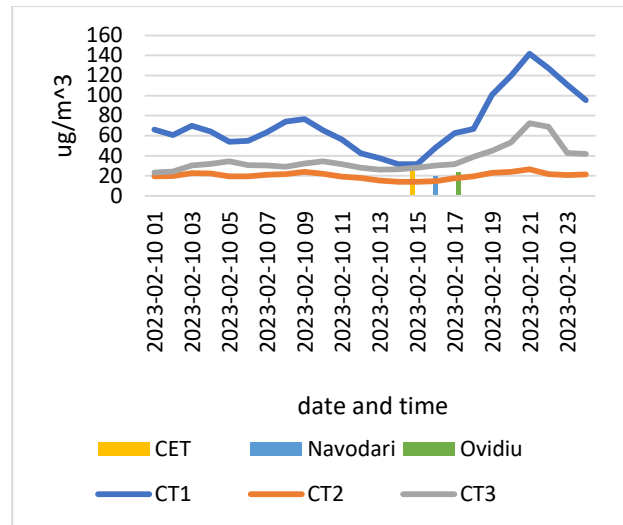


Figure 6 Hourly variation of PM10 concentration compared to measured values. 10<sup>th</sup> February 2023

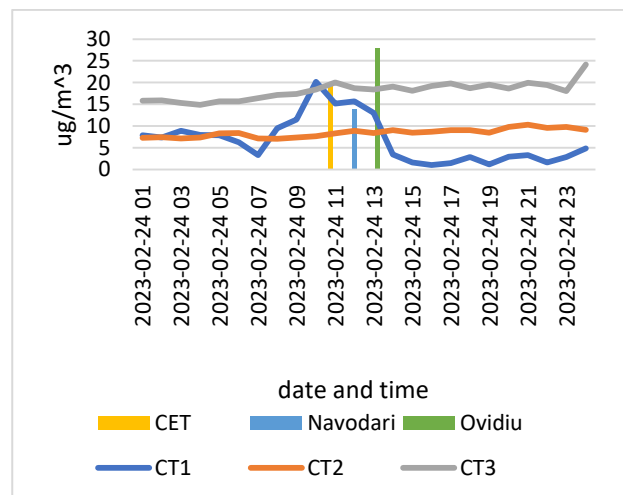


Figure 7 Hourly variation of PM10 concentration compared to measured values. 24<sup>th</sup> February 2023

The PM10 concentration value measured at CET on 24<sup>th</sup> February at 11.00 AM of 20 µg/m<sup>3</sup> is between the concentration values recorded at CT1 at 10.00 AM and 11.00 AM, 20.17 µg/m<sup>3</sup> and 15.16 µg/m<sup>3</sup> respectively. The APM sensor - CT2, recorded values of 8 - 9 µg/m<sup>3</sup> during the same period. The value measured at Năvodari at 12.00, 14 µg/m<sup>3</sup>, is below the value provided by the CT3 sensor at the same time, i.e. 18.69 µg/m<sup>3</sup>. On Ovidiu Waterfront, at 13.00 the highest PM10 value of that day was measured, i.e. 28 µg/m<sup>3</sup>, exceeding the maximum recorded at CT3 at 24.00 (24,13 µg/m<sup>3</sup>) (Figure 7). For 24<sup>th</sup> February 2023 the PM10 hourly averages place the air quality in the “acceptable” quality class.

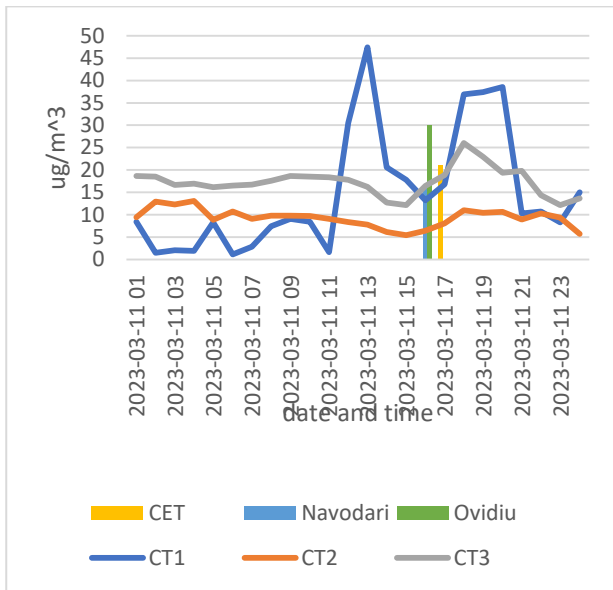


Figure 8 Hourly variation of PM10 concentration compared to measured values. 11<sup>th</sup> March 2023

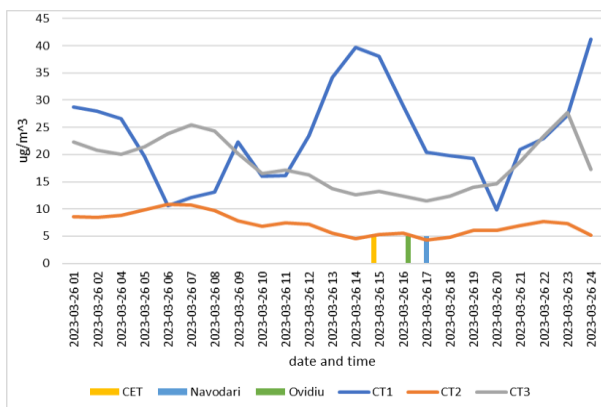


Figure 9 Hourly variation of PM10 concentration compared to measured values. 26<sup>th</sup> March 2023

On 11<sup>th</sup> March, at 16.00, at Năvodari, the measured value of  $16 \mu\text{g}/\text{m}^3$ , matches the hourly average of the CT3 sensor -  $16.46 \mu\text{g}/\text{m}^3$ , and at CET the value of  $21 \mu\text{g}/\text{m}^3$  at 17.00 exceeds the CT1 hourly average of  $16.84 \mu\text{g}/\text{m}^3$ . Again, at Ovidiu the highest PM10 concentration was measured, i.e.  $30 \mu\text{g}/\text{m}^3$ , which exceeds the hourly maximum recorded at CT3 with the value of  $26.05 \mu\text{g}/\text{m}^3$  (Figure 8). The hourly averages recorded by the APM sensors in the Constanța metropolitan area classify the air in the “moderate” quality class.

On 26<sup>th</sup> March the PM10 concentration measured in the 3 monitoring points were below those recorded by APM sensors in Constanța and Năvodari and had the same value of  $5 \mu\text{g}/\text{m}^3$ . Thus, at CET the measured PM10 concentration is close to the hourly average recorded by CT2 -  $5.26 \mu\text{g}/\text{m}^3$ . The values measured at Năvodari and Ovidiu Waterfront are below the hourly average of  $11.45 \mu\text{g}/\text{m}^3$  recorded at CT3 (Figure 9). The

hourly averages recorded by the APM sensors place the air in the “moderate” quality class.

Values below the averages recorded by the APM sensors were also measured on 12<sup>th</sup> April 2023, except that the value on the Ovidiu waterfront at 16.00 of  $6 \mu\text{g}/\text{m}^3$  and that in Năvodari at 17.00 of  $7 \mu\text{g}/\text{m}^3$  are close to the CT3 (Năvodari) hourly averages of  $7.22 \mu\text{g}/\text{m}^3$  at 16.00 and  $8.65 \mu\text{g}/\text{m}^3$  at 17.00 respectively (Figure 10).

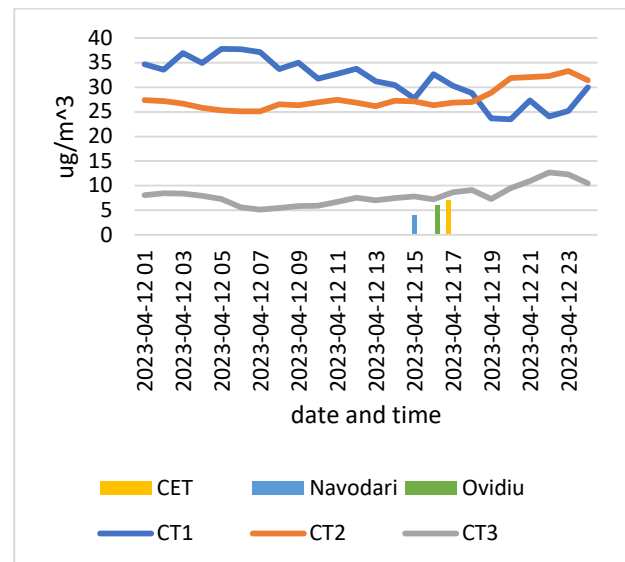


Figure 10 Hourly variation of PM10 concentration compared to measured values. 12<sup>th</sup> April 2023

Hourly averages from 12<sup>th</sup> April 2023, recorded by APM sensors in the Constanța metropolitan area, classify the air quality as “acceptable”.

On 28<sup>th</sup> April 2023, the measurements taken between 17.00 and 18.00 at the three locations in the Constanța metropolitan area, had a value of  $5 \mu\text{g}/\text{m}^3$  close to the CT3 hourly average recordings of  $6.36 \mu\text{g}/\text{m}^3$  at 17.00,  $7.28 \mu\text{g}/\text{m}^3$  at 18.00 and  $5.56 \mu\text{g}/\text{m}^3$  at 19.00 respectively. The hourly averages from sensors in Constanța varied between  $14.23 \mu\text{g}/\text{m}^3$  and  $21.17 \mu\text{g}/\text{m}^3$  for CT1 and  $29.66 \mu\text{g}/\text{m}^3$  and  $31.96 \mu\text{g}/\text{m}^3$  for CT2 (Figure 11). The hourly averages recorded by APM sensors in the Constanța metropolitan area place the air in the “acceptable” quality class.

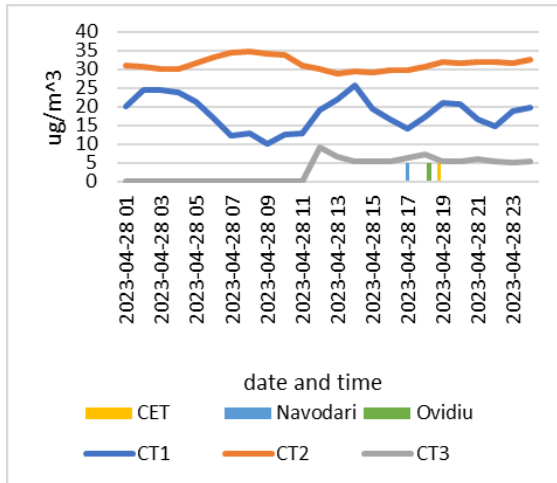


Figure 11 Hourly variation of PM10 concentration compared to measured values. 28<sup>th</sup> April 2023

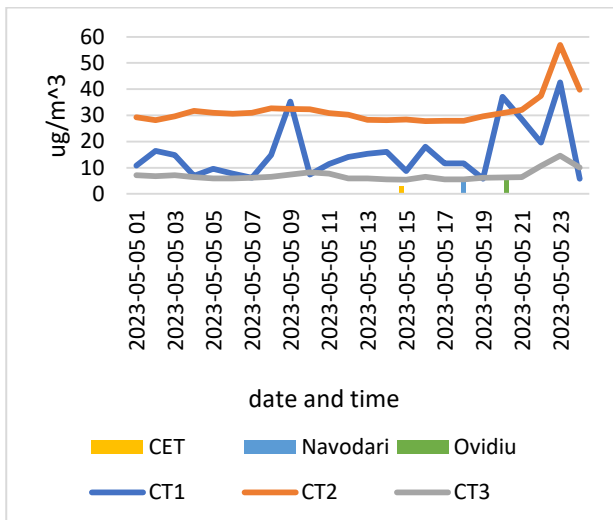


Figure 12 Hourly variation of PM10 concentration compared to measured values. 5<sup>th</sup> May 2023

A similar situation is observed on 5<sup>th</sup> May 2023, when the measured values of 3  $\mu\text{g}/\text{m}^3$  at CET and 5  $\mu\text{g}/\text{m}^3$  in Năvodari and Ovidiu Waterfront are close to the hourly averages of CT3 in Năvodari, which vary between 5.41  $\mu\text{g}/\text{m}^3$  and 6.27  $\mu\text{g}/\text{m}^3$  in the hourly interval in which the measurements with the portable monitor were carried out. The hourly average sensor values in Constanta ranged from 8.68  $\mu\text{g}/\text{m}^3$  to 37.15  $\mu\text{g}/\text{m}^3$  for CT1 and from 27.75  $\mu\text{g}/\text{m}^3$  to 32.14  $\mu\text{g}/\text{m}^3$  for CT2 (Fig. 12). On 28<sup>th</sup> April 2023, measurements taken between 17.00 and 18.00 at three locations in the Constanta metropolitan area had a value of 5  $\mu\text{g}/\text{m}^3$  close to the CT3 hourly average recordings of 6.36  $\mu\text{g}/\text{m}^3$  at 17.00, 7.28  $\mu\text{g}/\text{m}^3$  at 18.00 and 5.56  $\mu\text{g}/\text{m}^3$  at 19.00, respectively. The hourly averages from the Constanta sensors ranged from 14.23  $\mu\text{g}/\text{m}^3$  to 21.17  $\mu\text{g}/\text{m}^3$  for CT1 and from 29.66  $\mu\text{g}/\text{m}^3$  to 31.96  $\mu\text{g}/\text{m}^3$  for CT2 (Figure 12).

The hourly averages from 5<sup>th</sup> May 2023, recorded by APM sensors in the Constanta metropolitan area classify the air quality as “bad”.

On completion of this study, the values measured by the portable air quality meter are found to be in the same order of magnitude as the hourly averages recorded by the APM sensors. Between the 3 points of the Constanta metropolitan area monitored with respect to air quality, no variations greater than 50% were recorded. Increased values of carbon dioxide and particulate matter during the cooler period of the year are highlighted for all 3 points where measurements were taken. The hourly average PM10 values recorded in the Constanta Culture House Area, at TC1 show, unlike the other 2 stations, evident oscillations over 24 hours, which leads to the conclusion that air quality in this area is influenced by anthropogenic activity in a much more pronounced manner. Moreover, this station is an urban traffic type station, unlike the other 2 stations: CT2 - urban background type station and CT3 - suburban background type station.

#### 4. CONCLUSIONS

This article on the analysis of environmental quality in the Metropolitan Area of Constanta has highlighted the following aspects:

1. The concentration values of some environmental parameters obtained from measurements at 3 points in the metropolitan area, CET Constanta, Midia Năvodari and Ovidiu Waterfront, areas where the risk of impact of anthropogenic activities is higher, were classified as good, acceptable or slightly polluted.
  2. In general, air quality was poorer in February - March, influenced by the exhaust from heating systems.
  3. Total volatile organic compounds were recorded with the highest concentration in the Midia Năvodari area.
  4. Formaldehyde and carbon dioxide showed the highest values in the CET Constanta area.
  5. The highest concentration of particulate matter was recorded in the Ovidiu Waterfront area, probably under the influence of the heavy traffic nearby.
  6. However, there are small differences, between 13% and 45%, in the average concentration of pollutants in the 3 monitored points.
  7. The measured values are within the daily averages reported by the National Air Quality Monitoring Network and uRad Monitor.
  8. The hourly oscillations of the values of environmental factors in the area of the House of Culture, provided by the National Air Quality Monitoring Network, allow the conclusion that air quality in this area is influenced by anthropogenic activity in a much more pronounced manner.
- Metropolitan areas, characterised by concentrations of activities and population, can maintain a balance with environmental quality through appropriate measures taken at local level, according to the needs of the



moment. This requires identifying and monitoring environmental risks in the area.

## 7. REFERENCES

[1] <https://romania.europalibera.org/a/recensamant-zone-metropolitane/32216054.html>

[2] Fioretti, C., Pertoldi, M., Busti, M. and Van Heerden, S. editor(s), 2020, *Handbook of Sustainable Urban Development Strategies*, EUR 29990 EN 30285 EN (Exec Summ), Publications Office of the European Union, Luxembourg

[3] European Commission (EC), Directorate-General for Regional and Urban Policy, *Cities of tomorrow. Challenges, visions, ways forward*, Brussels, 2011

[4] Ghita S., Hnatiuc M., 2018, *Studies concerning flora from different protected areas in Constanta county by applying ecological and statistical methods*, Journal of Marine Technology and Environment, vol.1, pp 23-28, Nautica publishing House, Constanta, Romania.

[5] Nichita E., Panaitescu M., Panaitescu F.V., 2016, *Data of pollution on surface water and groundwater*, Journal of Marine Technology and Environment, vol.2, pp 39-42, Nautica publishing House, Constanta, Romania.



## EVALUATION OF DIFFERENT INTERPOLATION METHODS VIA ArcGIS, APPLIED TO SATELLITE DATA OF SEA SURFACE TEMPERATURE SST, CASE OF THE ALBORAN SEA

RAISSOUNI Ahmed<sup>1</sup>, Abdessalam Ben Harra<sup>1</sup>, Ayoub Belattmania<sup>1</sup>, Samia elallati<sup>1</sup>, Lhoussaine Ed-daoudy<sup>1</sup>, LAKZIZ Jawad<sup>2\*</sup> & Abdelkrim El Arrim<sup>1</sup>

<sup>1</sup> Marine Environment and Natural Hazard Research Team, Faculty of Sciences and Techniques of Tangier, University Abdelmalek Essaâdi, BP 416, 90 000, Tangier – MORROCO.

<sup>2</sup> University Hassan II Casablanca, MOROCCO, email: lakziz.jawad@gmail.com

**Abstract:** In various fields such as Oceanography, interpolation methods are pivotal in generating continuous surface data from discrete point data. This research endeavors to conduct a comprehensive comparison and evaluation of deterministic interpolation techniques, including Radial Basis Function (RBF), Inverse Distance Weighting (IDW), and geostatistical methods like Kriging Universal (KU) and Kriging Ordinary (KO), in the context of mapping sea surface temperature (SST) within the Alboran Sea.

Among these methods, the KO interpolation method emerges as particularly promising, boasting a Root Mean Square Error (RMSE) of 0.035 and an impressive coefficient of determination ( $R^2$ ) approaching unity (0.999). Furthermore, the cross-validation results reveal that the KO method not only provides the most accurate estimates but exhibits minimal bias, as evidenced by a mean error close to zero. These findings not only contribute to the field of SST mapping but also have broader implications for the interpolation of other climate parameters.

**Key words:** Sea surface temperature (SST), IDW, Kriging Ordinary (KO), Kriging Universal (KU), Radial Basis Function (RBF), Alboran Sea.

### 1. INTRODUCTION

Sea surface temperature (SST) is a physical and oceanographic parameter that has been studied and observed for a long time. Knowledge of this parameter is fundamental for oceanographers, meteorologists, and climatologists, as it is one of the results of the exchange of heat between the ocean and the atmosphere. The need for mapping in the daily lives of decision-makers has led to the emergence of Geographic Information Systems (GIS). The objective of GIS is to produce geographical data, process the geo-located information to visualise maps, and make decisions.

Spatial modelling techniques have developed considerably in recent years, thanks to the evolution of computer science. On one side, geostatistical processing software has been enhanced with simplified tools for geographic representation and, more recently, with import/export functions to communicate with GIS software, on the other side, GIS software has integrated spatial modelling tools through specialised extensions. Remote sensing has been used as an advantageous tool to improve knowledge of oceanographic aspects.

Spatial interpolation plays an important role in oceanographic data to create spatially continuous surface data. Interpolation methods are many and vary greatly in complexity and effectiveness [1]. Among the techniques that seem to be most frequently used in practice are the barycentric inverse distance methods (IDW) and classical kriging techniques such as ordinary kriging [2]. In this respect, we take as an example the interpolation of SST data in the Alboran Sea. The aim is to apply the four known and most commonly used methods, namely inverse distance weighting (IDW), kriging ordinary (KO), kriging universal (KU), and radial basis function (RBF).

The four methods have been exploited and compared to show the best spatial interpolation performances to present the SST data of the Alboran Sea, and to obtain these models, we used as GIS software the famous ArcGIS software. Commonly used methods, namely Inverse Distance Weighting (IDW), Kriging Ordinary (KO), Kriging Universal (KU), and Radial Basis Function (RBF). The four methods have been exploited and compared to show the best spatial interpolation performances in order to present the SST



data of the Alboran Sea. To obtain these models, we used as GIS software the famous ArcGIS software.

## 2. AREA OF APPLICATION

With a mean depth of 445 m and maximum depth of 1500 m, Alboran Sea, which fills the westernmost part of the Algerian-Provençal Basin (Sea-Mediterranean), is a very special maritime space. It is the entrance and exit of the Mediterranean Sea and the point of contact between the two continents, Africa and Europe (Figure 1). [3] The Strait of Gibraltar bounds this area to the west, the Iberian Peninsula to the North, and the Maghreb to the South. The sea is also an ecoregion designated by the World Wide Fund for Nature (WWF). It takes its name from the islet of Alboran, located halfway between the cities of Almeria and Melilla. Many commercial and passenger ports are located on both sides of this sea.



Figure 1 The geographical location of the study area

It is a highly dynamic area of the basin with marked mesoscale variability [3]. This region is characterised by two large anticyclonic gyres [4]; [5].

## 3. METHODOLOGY

### 3.1 Overview of interpolation methods

Interpolation is a mathematical process of predicting the values of unknown locations based on surrounding measured values [6]. Interpolation requires two basic assumptions about the surface: that the surface is continuous and smooth, and that the neighbouring data points have a strong correlation with the unknown area [7].

There are different interpolation techniques for creating surfaces, including IDW, spline, TIN, natural neighbour, and kriging, all of which can create different DTMs of surfaces even when constructed from the same data sources [8].

### 3.2 Inverse Distance Weighted (IDW)

As is obvious from the name of the interpolation technique, the weighting factor is inversely proportional to the distance [9].

Among the so-called deterministic interpolation methods is the inverse distance weighting method, which is often referred to in the literature by the acronym IDW (Inverse Distance Weighted). It is based on the principle that, for a given variable, the relative influence of an observation point decreases with the distance separating it from the point in space whose value is to be estimated [10]. The measurements of the surrounding observation points are averaged, with greater weight given to the closest points. The predicted value for a point in space is:

$$Z = \frac{\sum_{i=1}^N \frac{Z_i}{d_i^k}}{\sum_{i=1}^N \frac{1}{d_i^k}} \quad (1)$$

While:

Z : is the estimated variable.

Z<sub>i</sub> : is the known value at measurement point i.

N : is the number of sites used for the interpolation.

d : is the distance between the unknown value point and the measurement point i.

k : is the power to which the distance is raised.

### 3.3 Radial Basis Function (RBF)

The RBF interpolation is made more flexible than polynomial interpolation by using a voltage parameter that controls the behaviour of the interpolation function and the smoothing parameter [1]. It is an exact deterministic interpolation method that includes different basis functions depending on the distance between the interpolated point and the sample points. A radial basis function is a function of the form:

$$S(x) = p(x) + \sum_{i=1}^n \lambda_i \phi(\|x - x_i\|) \quad (2)$$

With:

S : is the radius basis function.

P : is a low-degree polynomial, usually linear.

λ<sub>i</sub> : coefficient of RBF.

x<sub>i</sub> : The center point of the RBF.

φ : is a real-valued function also called the basis function.

### 3.4 Kriging

Kriging is a stochastic spatial interpolation method that takes into account the spatial dependence structure of the data. The mining engineer D.G. Krige [11] first proposed this method [12]. There are several kriging methods, among which we used in this study: kriging universal (KU) and kriging ordinary (KO).

The kriging method uses the semi-variogram or variogram to assign weights to observation points during the spatial interpolation process. The semi-variogram  $\gamma(h)$  is expressed by the following formula:

$$\gamma(h) = \frac{\sum_{i=1}^{N(h)} [Z(x_i + h) - Z(x_i)]^2}{2N(h)} \quad (3)$$

With :

- $Z$  is the variable to be interpolated.
- $N(h)$  is the number of pairs of points  $x_i$  where the value of this  $Z$  is known, separated by a distance  $h$ .

### 3.4.1 Kriging Ordinary (KO)

Kriging Ordinary (KO) is one of the three main types of kriging that has been adopted to improve on Kriging Simple (KS) and requires that the expectation of the random function  $Z(x)$  be known. It uses the fitted semi-variogram, a diagram relating the semi-variance to the distance between the samples points used in kriging. The KO estimator is given by the following equation [13]:

$$Z^*(x_0) = \sum_{i=1}^n \lambda_i Z(x_i) \quad (1)$$

Where :  $Z^*(x_0)$  is the estimated value at  $x_0$ ,  $z(x_i)$  is the measurement value at  $x_i$  and  $\lambda_i$  is the weight assigned to the residual of  $z(x_i)$  [13].

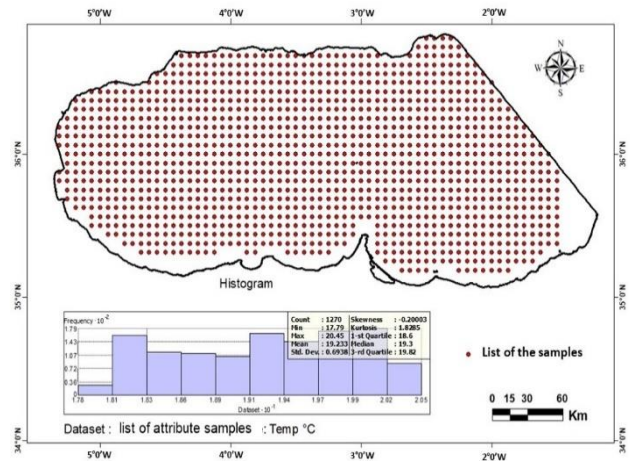
### 3.4.2 Kriging Universal (KU)

Like KU, kriging universal (UK) is also a main type of kriging. Hence the idea of universal kriging (trend kriging), where the local neighbourhood trend is modelled as a smoothly varying function [14]; [15].

### 3.5 Application data

In this study, we used a NetCDF file (Network Common Data Form); a file format that allows storing multidimensional scientific data in a compressible format in the form of arrays of numbers of daily SST data (Figure. 2), recorded between November 10 and November 26, 2020, in the Alboran Sea. These data were obtained via <https://marine.copernicus.eu/access-data>. The data processing was carried out by ArcGIS software in its version 10.4 with the "geostatistical analysis" extension.

ArcGIS was used to apply the four methods of interpolation of the SST data and to produce the different maps as well as the cross-validation.



### 3.6 Evaluation tests and cross-validation

In this step, we rely on the following statistical parameters to evaluate the quality of the interpolation methods:

- ✓ The Root Mean Square Error (RMSE):

$$RMSE = \sqrt{\frac{1}{n} \sum_{i=1}^n (Z_{mne} - z_t)^2} \quad (2)$$

With:  $Z_{mne}$  is the predicted value at point  $i$ ,  $Z_t$  is the observed value, and  $n$  is the number of validated points.

- ✓ The coefficient of determination of the model  $R^2$ , whose value is between 0 and 1. The  $R^2$  is interpreted as the proportion of the variability of the dependent variable explained by the model.

To confirm the results, the cross-validation technique was used, which compares the measured values with the interpolated values using only the information available in the sample data set.

## 3. RESULTS & DISCUSSION

The results of the statistical parameters obtained by the four interpolation methods are summarised in Table 1.

The RMSE values vary relatively widely, between 0.035 and 0.063 °C. The KO interpolation methods generally produce the lowest RMSE, while the IDW produces the highest. Intermediate MSE values are marked for both K.U and RBF interpolation methods (Table .1). The coefficient of determination of the model  $R^2$  is a coefficient with a value between 0 and 1. For our study, all the interpolation methods have  $R^2$  values very close to 1 (Table .1) but the value closest to 1 is that of the K.O method ( $R^2 = 0.999$ ). However, based on the

results of these parameters, the KO interpolation method is the best interpolation method for SST.

Table 1. Statistical description of the KO, KU, RBF, and

Interpolation method	Min	Max	Mean	RMSE	R <sup>2</sup>
Kriging Ordinary	17.81	20.44	19.23	0.035	0.999
Kriging Universal	17.85	20.41	19.23	0.050	0.998
RBF	17.80	20.48	19.23	0.050	0.997
IDW	17.88	20.38	19.24	0.063	0.996

IDW methods.

To confirm this result, we used the cross-validation technique (Fig.3).

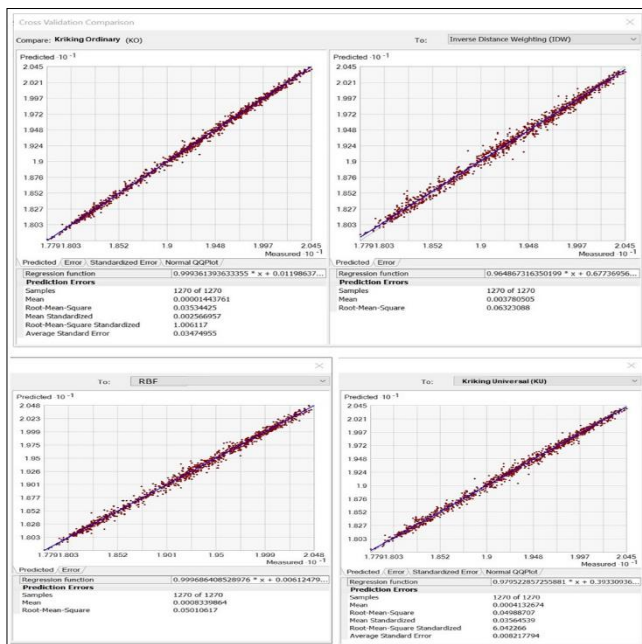


Figure 3 The comparison of the four interpolation methods KO, IDW, RBF, and KU by cross-validation.

The comparison of the two Kriging methods KO and KU, Figure 3 shows that the interpolation by the KU method presents us with a high value of the mean error (0.0004 °C) compared to the one obtained by the KO (0.00001 °C). As for the RMSE values, KO method has a lower value (0.035 °C) than the one obtained by KU (0.05 °C).

This reflects that the KO method is better than KU for interpolating SST. The slope of the linear regression is also a parameter to distinguish between the two methods. In fact, the KO method has a higher slope value (0.999) than the of KU method (0.979), thus

corroborating the performance of the KO method compared to the KU method.

The comparison between the KO method and the RBF method is shown in (Figure .3). Again, the KO method shows a low value of the mean error (0.00001 °C) compared to that obtained by the RBF method (0.00083 °C). As for the RMSE, the value obtained by RBF (0.05 °C) is higher than that given by KO (0.035 °C). These results show that the KO method is more reliable and accurate than the RBF method and the slope of the linear regression for both methods shows that they are almost similar.

As for, the comparison of the KO method and the IDW method (Figure .3), it shows that the interpolation by the KO method has a low value of the mean error (0.00001 °C) compared to that given by the IDW (0.0037 °C). As for the RMSE value, the IDW method has a value almost twice as high (0.06 °C) as that obtained by the KO (0.035). This suggests that the KO method is more accurate than the IDW method. The slope of regression line of the KO method (0.999) is higher than that of IDW method (0.964).

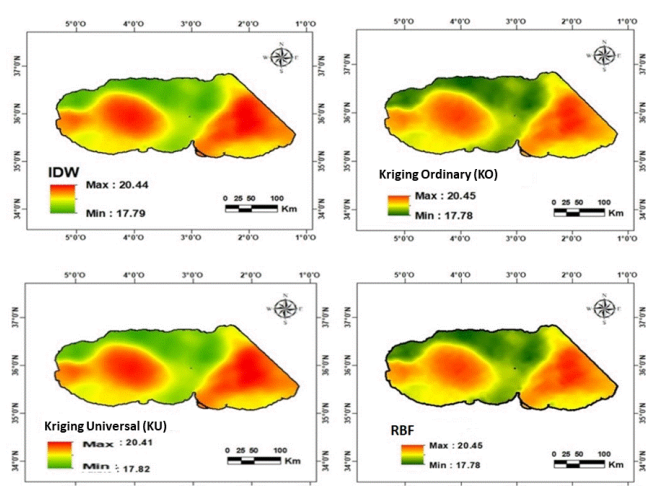


Figure 4 The SST maps obtained by the four interpolation methods IDW, KO, KU, and RBF.

The spatial distribution of the SST data obtained by the four interpolation methods showed that an area with low temperatures 17.78 to almost 19.25 °C, located in the centre of the application area, is interspersed between two areas with temperatures ranging from 19 to 20.45 °C Figure 4.

When discussing the four interpolation methods, it can be seen that the dispersion keeps more or less the same spatial distribution with all four methods. However, when looking at the average spatialization errors obtained, it can be seen that the three methods KU, RBF and IDW lead to larger overestimates than the KO method. Based on these results, it can be said that the KO interpolation is the most adequate method to predict SST than the KU, RBF and IDW methods.



## 5. CONCLUSION

In conclusion, this research has undertaken a comprehensive evaluation of various interpolation methods applied to sea surface temperature (SST) data within the Alboran Sea. Through rigorous analysis, we have established that interpolation techniques, including the Radial Basis Function (RBF), Inverse Distance Weighting (IDW), and geostatistical methods such as Kriging Universal (KU) and Kriging Ordinary (KO), all hold promise for generating continuous surface data from discrete point data in oceanographic studies.

The findings of this study have unveiled noteworthy insights. While all methods exhibited similar performance metrics in terms of Root Mean Square Error (RMSE) and Pearson correlation, the Kriging Ordinary (KO) method emerged as the frontrunner. With an impressively low RMSE of 0.035 and a near-unity coefficient of determination ( $R^2$ ), the KO method demonstrated its exceptional capability for SST interpolation. The Kriging Universal (KU) method, with an RMSE of 0.05 and an  $R^2$  of approximately 0.998, followed closely in terms of accuracy. The Radial Basis Function (RBF) method and Inverse Distance Weighting (IDW) method exhibited intermediate to good performance, offering valuable alternatives.

These findings not only enhance the field of SST mapping but also offer valuable insights for a broader spectrum of climate-related studies, contributing to the advancement of scientific knowledge and practical applications in Oceanography and Meteorology.

## 6. REFERENCES

- [1] Drapeau L., « Statistiques et Interpolations dans les SIG », *Towards the use of Geographic Information Systems as a Decision Support Tool for the Management of Mediterranean Fisheries. COPEMED*, [http://www.faocopemed.org/old\\_copemed/vldocs/0000028/publi10.pdf](http://www.faocopemed.org/old_copemed/vldocs/0000028/publi10.pdf), (2000).
- [2] Baillargeon S., « Le krigeage: revue de la théorie et application à l'interpolation spatiale de données de précipitations, mémoire présenté pour l'obtention du grade de Maître ès Sciences (M. Sc.) », *Université de Laval, Faculté des Sciences et de Génie, Québec, disponible en ligne à <http://www.theses.ulaval.ca/2005/22636/22636.pdf>*, (2005).
- [3] Rogé M., « Etudes de cartographie altimétrique pour l'observation de la dynamique méso-échelle dans le contexte SWOT: application à la mer Méditerranée occidentale », *phdthesis, Université Paul Sabatier - Toulouse III*, 2018.
- [4] Tintore J. et al., « A Study of an Intense Density Front in the Eastern Alboran Sea: The Almeria-Oran Front », *Journal of Physical Oceanography*, vol. 18, n° 10, (oct. 1988), p. 1384-1397. [https://doi.org/10.1175/1520-0485\(1988\)018<1384:ASOAIID>2.0.CO;2](https://doi.org/10.1175/1520-0485(1988)018<1384:ASOAIID>2.0.CO;2)
- [5] Arnone R. A. et al., « The origin and characteristics of the Algerian Current », *Journal of Geophysical Research: Oceans*, vol. 95, n° C2, (1990), p. 1587-1598. <https://doi.org/10.1029/JC095iC02p01587>
- [6] Burrough P. A. et McDonnell R. A., « Principles of Geographical Information Systems Oxford: Oxford University Press », (1998).
- [7] Liu X. et al., « LiDAR-derived high quality ground control information and DEM for image orthorectification », *GeoInformatica*, vol. 11, (2007), p. 37-53.
- [8] Maune D. F. et al., « Introduction: Digital Elevation Models, Digital Elevation Model Technologies and Applications: The DEM Users Manual ». American Society for Photogrammetry and Remote Sensing, Maryland, 2007.
- [9] Ashraf M. et al., « Application of geostatistics to evaluate partial weather station networks », *Agricultural and forest meteorology*, vol. 84, n° 3-4, (1997), p. 255-271.
- [10] Bois B., « Cartographie agroclimatique à méso-échelle: méthodologie et application à la variabilité spatiale du climat en Gironde viticole. Conséquences pour le développement de la vigne et la maturation du raisin », *PhD Thesis, Université Sciences et Technologies-Bordeaux I*, 2007.



[11] Krige D. G., « A statistical analysis of some of the borehole values in the Orange Free State goldfield », *Journal of the Southern African Institute of Mining and Metallurgy*, vol. 53, n° 3, (1952), p. 47-64.

[12] Ben Salah F., « Modélisation de la propagation des incertitudes des mesures sur l'aube d'une turbine hydraulique par Krigeage et simulations stochastiques », PhD Thesis, École de technologie supérieure, 2014.

[13] Sun Y. et al., « Comparison of interpolation methods for depth to groundwater and its temporal and spatial variations in the Minqin oasis of northwest China », *Environmental Modelling & Software*, vol. 24, n° 10, (2009), p. 1163-1170.

[14] Armstrong M., « The Theory of Kriging », in *Basic Linear Geostatistics*, Armstrong M. éd. Berlin, Heidelberg: Springer, 1998, p. 83-102. [https://doi.org/10.1007/978-3-642-58727-6\\_7](https://doi.org/10.1007/978-3-642-58727-6_7)

[15] Matheron G., *Le krigeage universel*, vol. 1. École nationale supérieure des mines de Paris Paris, 1969.



## EXPERIMENTAL RESEARCH ON THE PRESENCE OF HYDROCARBONS IN THE SOIL OF THE NORTH CONSTANTA ZONE

VASILICĂ Florentina-Aurelia<sup>1</sup>, SAFTA Carmen-Anca<sup>1, 2</sup>, PANAITESCU Mariana<sup>2</sup>,  
PANAITESCU Fanel-Viorel<sup>2</sup>, VOICU Ionut<sup>2</sup>

<sup>1</sup> National University of Science and Technology POLITEHNICA BUCHAREST, Bucharest-Romania, Blvd. Spl.Independentei, no. 313, sector 6, 060042, Bucharest, Romania  
e-mail: vasilica.florentina16@gmail.com, safta.carmenanca@gmail.com

<sup>2</sup> Constanta Maritime University, Faculty of Electromechanics, 104 Mircea cel Batran Street, 900663 Constanta, Romania

e-mail: panaitescumariana1@gmail.com, viopanaitescu@yahoo.ro, ionut.voicu@cmu-edu.eu

**Abstract:** This experimental research engages in an investigation of sediment quality, with a focus on the identification and quantification of hydrocarbons and other contaminants that may adversely affect the health of the marine and terrestrial ecosystem in the Black Sea region. The purpose of this experimental research is to contribute to the understanding of the dynamics of hydrocarbon pollution and its impact on the marine and terrestrial environment in the Black Sea area.

**Key words:** Black Sea, pollution, soil, hydrocarbs

### 1. INTRODUCTION

The global environmental problems facing humanity today are largely the result of human overexploitation of natural resources, namely (fossil) fuels, minerals, water, soil and biodiversity. [1]

Water is a valuable resource under pressure in Europe, with only 40% of surface water bodies in good ecological status and 38% in good chemical status.

Water and soil are two fundamental elements of the marine and terrestrial ecosystem, and their quality is vital for the conservation of biodiversity and the maintenance of environmental health. In the Black Sea area, one of the most important and sensitive marine ecosystems in the world, sediment and hydrocarbon analyses in water and soil have become increasingly relevant in the context of increasing anthropogenic pressures and climate change.

This experimental research engages in an investigation of sediment quality with a focus on the identification and quantification of hydrocarbons and other contaminants that may adversely affect the health of the marine and terrestrial ecosystem in the Mamaia Nord area.

### 2. EXPERIMENTAL DATA FROM THE NORTH CONSTANTA COASTAL AREA FOR SOIL

Petroleum products tend to settle on the bottom of the basin, covering especially the species that have a high degree of mobility. In this case, entire colonies of

organisms that naturally constitute food for fish are destroyed by poisoning or asphyxiation.[4]

To determine the degree of soil pollution in the Romanian coastal area of the Black Sea, for the period 2021-2023, samples of dredged material were taken, which were analysed in specialized laboratories, accredited by RENAR, to determine the chemical indicators.

To compare the obtained values and determine the alert threshold, the reference values were used according to Order no. 756/1997 for the approval of the Regulation on environmental pollution assessment. The regulation regarding the classification of surface waters, annex B for: heavy metals (cadmium, copper), pesticides (sum of DDD/DDT/DDE), total polynuclear aromatic compounds (sum of PAH). Total polychlorinated biphenyl compounds (PCB amounts), mononuclear aromatic compounds (benzene, toluene, phenols).[2]

In the calculation of the standard deviation, from this chapter, the results for polycyclic aromatic hydrocarbons were used. Standard deviation is a measure of the dispersion or variability of data in a statistical distribution. It is used in a variety of fields, including scientific research, financial analysis, engineering, psychology, and many other fields where it is important to understand the dispersion and variability of data.[3]

Polycyclic aromatic hydrocarbons (PAHs) are organic compounds containing two or more benzene rings. They are often considered persistent organic pollutants (POPs) and can accumulate in soil, water and living organisms, including the human body.[5]

### 3. METHODOLOGY AND RESULTS

#### 3.1 Methodology

The values resulting from the analysis of the material dredged from the Constanta North Coastal area in the period 2021-2020, in an accredited laboratory, are presented in Tables 2-4.

The values for Polycyclic Aromatic Hydrocarbons (PAH) in these areas were determined.

The coordinates of the areas where the samples were taken are presented in table 1.

Table 1. Sampling points

Name of section	Longitude
Constanta North coast	28,3858
Constanta North- 5 m	28,3858

#### 3.2 Results

##### 3.2.1. The variations of PAHs in period 2021-2023

The results of PAHs(Polycyclic Aromatics Hydrocarbons) were presented during period 2021-2023 on Constanta-North coast and on Constanta-North at 5 m depth from coast in the following tables (Table 1, Table 2, Table 3):

Table 2. PAH Results 2021

2021	Place of sampling	Constanta North coast	Constanta North- 5 m
Date of sampling		aug.21	aug.21
Parameter	Unit	Result	Result
Polycyclic Aromatics Hydrocarbons (PAHs)			
Naphthalene	mg/kg SU	0,03	0,015
Acenaphthylene	mg/kg SU	0,03	0,015
Acenaphthene	mg/kg SU	0,035	0,015
Fluorene	mg/kg SU	0,035	0,015
Phenanthrene	mg/kg SU	0,04	0,015
Anthracene	mg/kg SU	0,04	0,015
Fluoranthene	mg/kg SU	0,02	0,015
Pyrene	mg/kg SU	0,01	0,015
Benzo(a)anthracene	mg/kg SU	0,028	0,015

Chrysene	mg/kg SU	0,01	0,015
Benzo(b)fluoranthene	mg/kg SU	0,01	0,015
Benzo(k)fluoranthene	mg/kg SU	0,02	0,015
Benzo(a)pyrene	mg/kg SU	0,04	0,015
Indeno(1,2,3,cd)pyrene	mg/kg SU	0,06	0,015
Benzo(g,h,i)perylene	mg/kg SU	0,04	0,015
Dibenzo(a,h)anthracene	mg/kg SU	0,01	0,015
Amount of 16 PAH	mg/kg SU	0,45	0,24

Table 3. PAH Results 2022

2022	Place of sampling	Constanta North coast	Constanta North- 5 m
Date of sampling		aug.22	aug.22
Parameter	Unit	Result	Result
Polycyclic Aromatics Hydrocarbons (PAHs)			
Naphthalene	mg/kg SU	0,22	0,25
Acenaphthylene	mg/kg SU	0,19	0,18
Acenaphthene	mg/kg SU	0,17	0,17
Fluorene	mg/kg SU	0,1	0,1
Phenanthrene	mg/kg SU	0,18	0,17
Anthracene	mg/kg SU	0,15	0,15
Fluoranthene	mg/kg SU	0,1	0,1
Pyrene	mg/kg SU	0,1	0,1
Benzo(a)anthracene	mg/kg SU	0,1	0,1
Chrysene	mg/kg SU	0,1	0,1
Benzo(b)fluoranthene	mg/kg SU	0,1	0,1
Benzo(k)fluoranthene	mg/kg	0,11	0,11

hene	SU		
Benzo(a)pyrene	mg/kg SU	0,12	0,12
Indeno(1,2,3,cd) pyrene	mg/kg SU	0,13	0,13
Phenanthrene	mg/kg SU	0,14	0,14
Dibenzo(a,h)anth racene	mg/kg SU	0,13	0,13
Amount of 16 PAH 16 PAH	mg/kg SU	2,14	2,15

Dibenzo(a,h)anth racene	mg/kg SU	0,1	0,1
Amount of 16 PAH 16 PAH	mg/kg SU	1,88	1,85

Table 4. PAH Results 2023

2023	Place of sampling	Constanta North coast	Constanta North- 5 m
Date of sampling		aug.23	aug.23
Parameter	Unit	Result	Result
Polycyclic Aromatics Hydrocarbons (PAHs)			
Naphthalene	mg/kg SU	0,17	0,18
Acenaphthylene	mg/kg SU	0,18	0,17
Acenaphthene	mg/kg SU	0,13	0,11
Fluorene	mg/kg SU	0,14	0,12
Phenanthrene	mg/kg SU	0,11	0,11
Anthracene	mg/kg SU	0,1	0,1
Fluoranthene	mg/kg SU	0,1	0,1
Pyrene	mg/kg SU	0,1	0,1
Benzo(a)anthracene	mg/kg SU	0,1	0,1
Chrysene	mg/kg SU	0,1	0,1
Benzo(b)fluoranthene	mg/kg SU	0,1	0,1
Benzo(k)fluoranthene	mg/kg SU	0,13	0,12
Benzo(a)pyrene	mg/kg SU	0,11	0,12
Indeno(1,2,3,cd) pyrene	mg/kg SU	0,11	0,12
Phenanthrene	mg/kg SU	0,1	0,1

### 3.2.2. The standard deviation

After analysing the results obtained for the PAHs values, we calculated the standard deviation, and then we compared its result with the values imposed by the legislation.

The obtained results are presented in figures 1-3.

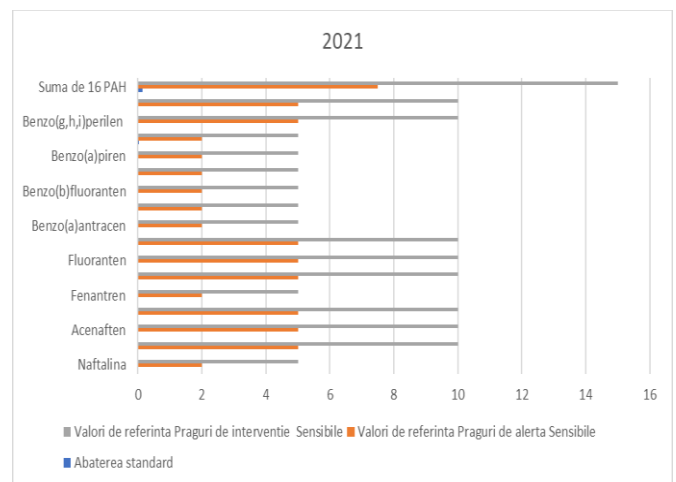


Figure 1 Comparison of reference values and standard deviation values-2021

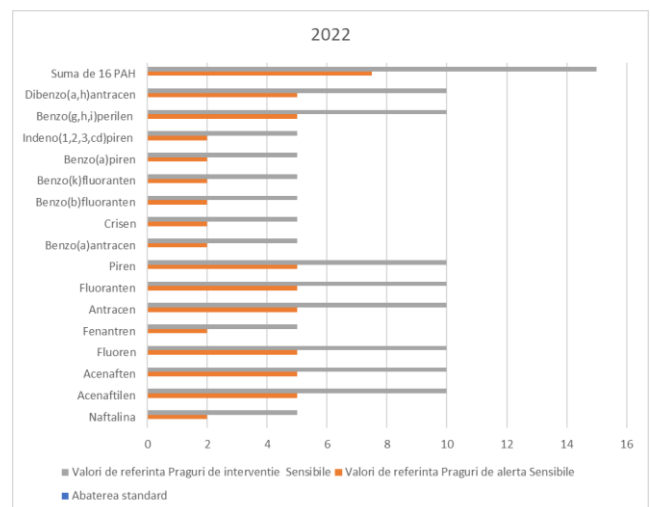


Figure 2 Comparison of reference values and standard deviation values-2022



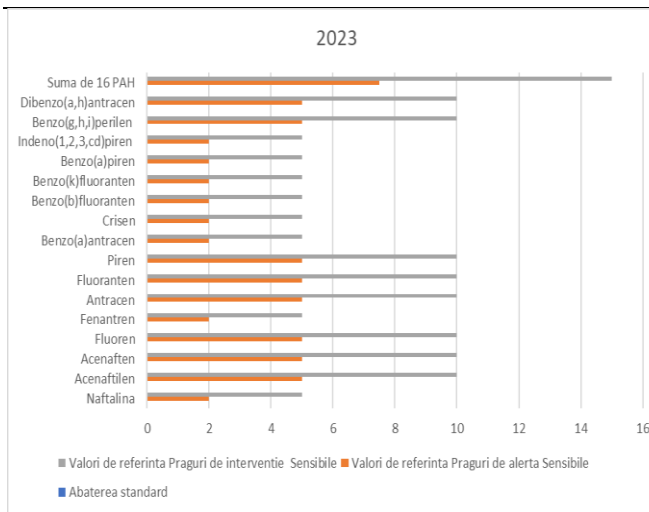


Figure 3 Comparison of reference values and standard deviation values-2023

For the period 2021-2023, the analyzed area of the Romanian Black Sea Coast was subject to minor pollution.

#### 4. CONCLUSIONS

The results of the analyzes indicate a stability of the environment in the area of the Black Sea Coast, with a reduced standard deviation regarding the concentrations of hydrocarbons and sediments in water and soil. This suggests that the area is generally less affected by pollution and that soil quality parameters remain relatively constant.

In conclusion, the results of experimental research indicate a general favorable state of the environment in the area of the Black Sea Coast, with a small standard deviation and a relatively unpolluted area. These findings represent an important starting point for conservation and environmental protection efforts in this region.

#### 7. REFERENCES

[1] <https://www.eea.europa.eu/ro/themes/waste/intro>

[2] <https://legislatie.just.ro/Public/DetaliiDocumentAfis/13572>

[3] [http://moodle.toxoer.com/pluginfile.php/3555/mod\\_page/content/1/Hidrocarburi%20aromatice%20polinuclear\\_e\\_Ro.pdf](http://moodle.toxoer.com/pluginfile.php/3555/mod_page/content/1/Hidrocarburi%20aromatice%20polinuclear_e_Ro.pdf)

[4] Panaitescu F V., Panaitescu M., Voicu I., 2019, Concepte de risc de mediu (Environmental risk concepts), Nautica Publishing House, Constanta, 95-96 .

[5] Avelino I. Mondlane, Dr. Mohmoud Hassanien, 2003, “*Environmental risk assessment: An approach toward environmental hazard and disaster risk management*”, 30th September 02nd October 2003), Proc.of Environment 2003 Conference Cairo EGYPT.

[6] GRANCHAROVA V., GRANCHAROV I., 2013, *SAFE ACCESS AND OPERATIONS WITHIN PORT AREA* ,Journal of Marine Technology and Environment, vol. 1, 2013, pp 73-78, Nautica Publishing House, Constanta, Romania.

[7] Panaitescu M., Panaitescu F.V., 2018, *ENVIRONMENTAL IMPACT OF POLLUTANTS ON SOIL AND SUBSOIL*, Journal of Marine Technology and Environment, vol. 2, 2018, pp 45-50, Nautica Publishing House, Constanta, Romania

[8] Andrei C., Lamba M.D., HANZU-PAZARA R., BLAGOVEST BELEV, *CONSIDERATIONS REGARDING THE IMPACT OF SHIP INTACT STABILITY LOSS ON MARINE POLLUTION*, Journal of Marine Technology and Environment, vol. 1, 2014, pp 7-16, Nautica Publishing House, Constanta, Romania



## DESCRIPTION OF TYPES OF RESEARCH

VOICU Ionuț<sup>1</sup>, VASILICĂ Florentina-Aurelia<sup>2</sup>

<sup>1</sup>Constanta Maritime University, Faculty of Naval Electro-Mechanics, 104 Mircea cel Batran Street, 900663, Constanta, Romania, e-mail address: ionut.voicu@cmu-edu.eu

<sup>2</sup>National University of Science and Technology POLITEHNICA Bucharest, Blvd. Spl.Independentei, no. 313, sector 6, 06004, Bucharest, Romania  
e-mail address: vasilica.florentina16@gmail.com

**Abstract:** Research is a form of knowledge whose content is given by the "creation" resulting from human curiosity, or better said, research activity. Scientific research is based on scientific knowledge and is a continuous search carried out within a complex process, the content of which is given by "scientific creation". The researcher's opinion is actually his answer, written in the form of a narrative, the content of which presents, in a logical and fluent structure, the staged development of the research activity, as well as the conclusions and results obtained as a result. When we discuss about types of research we are actually discussing different approaches that researchers can use to research a problem, a phenomenon or even a process. The methodology used in a research activity is often determined by the type of research being addressed. Therefore, there are different types of research, and each of them is conducted for a specific purpose, scope and type of data.

**Key words:** applied, deductive, descriptive, experimental, exploratory, primary, qualitative, quantitative, theoretical

### 1. INTRODUCTION

Research activity is an important and necessary part of any academic or professional duty, being used by both scientists and business people. This is defined as a systematic and structured investigation aimed at discovering or validating knowledge, insights or even solutions.

Depending on the purpose, scope and type of data used, research activity can be classified into different types.

### 2. PURPOSE

#### 2.1. Theoretical research

Theoretical research (TR) is used to build new theories and concepts that can be applied in different fields. Its purpose is to expand existing knowledge and to understand in detail a certain concept, phenomenon or topic.

This type of research involves testing existing hypotheses and theories and developing improved versions, respectively building models to explain the observed phenomena

#### 2.2. Applied research

The purpose of applied research (AR) is to solve practical problems and improve understanding of the real world.

This type of research involves using scientific methods and theories to develop practical solutions to concrete problems or challenges as opposed to pure research, which aims to expand knowledge without a concrete application in mind.

In this context, AR focuses on producing practical results that are further used in industry, medicine, public policy or other fields.

The main purpose of AR is to improve the ability to predict, control and manipulate real-world phenomena and processes in order to then create equally real benefits for society.

Whether we are talking about developing new technologies, improving existing products or creating new policies, AR plays a special role in developing knowledge and improving the ability to solve practical, concrete, everyday problems.

The three types of ARs are listed and detailed below:

a) Evaluation research (ER) is used to evaluate the effectiveness of programs, policies or interventions.

This involves collecting and analyzing data to determine whether the program, policy, or intervention is achieving its stated goals and objectives.

ER results are used to improve the program, policy or intervention, respectively to make the most

appropriate decisions to continue or even justify their funding.

Examples include evaluating the impact of a new public health policy, evaluating the effectiveness of a school program, or measuring the results of a social intervention.

b) Research and development (R&D) is a type of applied research that involves the creation of new products, processes or technologies.

Typically, R&D is carried out by companies or organizations that want to improve the performance of already existing products, make the services they provide more efficient, or simply innovate, develop, or produce new technologies.

R&D involves a systematic process of experimentation, testing and refinement with the aim of creating something new, innovative and useful.

Examples include developing a new medical treatment, designing a new technological product, or improving an existing manufacturing process.

c) Action-Research (A-R) is a collaborative approach that is proposed with the goal of real-time problem solving.

This type of applied research involves working with different stakeholders to identify and quickly solve practical problems and challenges and is used to address practical problems and challenges faced by companies, organizations or even communities.

A-R typically involves a cyclical process of problem identification, data collection, analysis, and solution implementation, and is often used in areas such as industry, education, healthcare, and social services.

Some examples include working with a community to develop a new poverty reduction program or working with a school to improve student achievement.

### 3. DATA TYPE

#### 3.1. Qualitative research

Qualitative research (Q-litaR) is a type of research that seeks to understand and interpret human behavior, experiences and social, economic, physical, chemical, etc. phenomena.

This type of research is often used when the research topic requires an in-depth understanding of the context, meaning and complexity of a phenomenon.

Research methods used within Q-litaR include interviews, focus groups, ethnographies and case studies. The data collected in this way is often non-numerical and is used to identify themes, patterns and meanings.

Q-litaR is commonly used in many fields, including sociology, anthropology, and psychology, and is particularly useful for exploring new topics, generating new hypotheses, and gaining a deep understanding of a phenomenon from the perspective of the people involved.

#### 3.2. Quantitative research

Quantitative research (Q-titaR) is a type of research that seeks to measure and analyze numerical data to test hypotheses, identify patterns, and make predictions.

This type of research is often used when the research question requires precise measurement of a phenomenon and statistical analysis.

Research methods used within Q-titaR include experiments, surveys and secondary data analyses. The data thus collected are often numerical, and they are analyzed using statistical methods to identify the relationships between the variables.

Q-titaR is commonly used in fields such as psychology, economics, and public health, where it is particularly useful for testing hypotheses and making generalizations about a population based on a sample.

This type of research is used to make evidence-based recommendations and to inform policy and practice in various research areas.

#### 3.3. Mixed methods research

Mixed methods research (MixR) combines the type of qualitative and quantitative research to obtain a complete picture of a certain phenomenon.

This type of research is often used when a single type of research cannot provide a complete understanding of the phenomenon to be researched

## 4. MANIPULATION OF VARIABLES

#### 4.1. Experimental research

Experimental research (ExpR) is a type of research that establishes cause-effect relationships between variables.

In this type of research, an independent variable is manipulated and its effects on a dependent variable are observed while controlling for extraneous variables.

This type of research involves the use of randomized controlled trials, so the data collected is often quantitative and statistical analysis is used to test hypotheses.

ExpR is a powerful tool for exploring causal relationships, but at the same time it has limitations such as the difficulty of generalizing real-world findings and ethical considerations related to the manipulation of variables.

Its findings can help inform policies and practices in various research fields, such as natural sciences, social sciences, medical sciences, engineering sciences, etc.

#### 4.2. Non-experimental research

Non-experimental research (N-expR) is a type of research that is used to observe and measure variables without manipulating them.

N-expR is often used in studies where it is not possible or ethical to manipulate variables, such as in studies involving human behavior or medical conditions.



Research methods used within N-expR include observational studies, surveys and case studies.

The data thus collected are often qualitative or quantitative, and the interpretation of the results is done with the help of statistical analysis.

Although, N-expR cannot establish causal relationships between variables, it can provide valuable information about the nature of the variables and identify potential areas for further research.

#### 4.3. *Quasi-experimental research*

Quasi-experimental research (Q-expR) is a type of research that combines elements of ExpR and N-expR.

In it, researchers manipulate an independent variable, but unlike ExpR, they do not use random assignment to assign participants to different experimental conditions.

Q-expR is frequently used in studies where it is not possible or practical to use random assignments, such as in studies involving preexisting groups or natural events.

Research methods used within Q-expR include interrupted time series, non-equivalent control group designs and regression discontinuity models. The data are often quantitative, and the interpretation of the results is done with the help of statistical analysis.

This research cannot establish causality as effectively as ExpR, but instead can provide valuable information on the relationship between variables and also help inform policy and practice in various research areas.

## 5. TYPE OF INTERFERENCE

### 5.1. *Deductive research*

Deductive research (DR) is a type of research that starts from a theory or hypothesis and then tests it using empirical data.

In DR, researchers begin by developing a clear and specific hypothesis that builds on a pre-existing theory or body of knowledge.

They collect data and use statistical analysis to test hypothesis and draw conclusions about the proposed theory.

DR is often used in the natural sciences, social sciences and medicine to test hypotheses, respectively to establish causal relationships between variables.

The data thus collected are often quantitative, and the interpretation of the results is done with the help of statistical analysis.

Although, DR can provide strong evidence to support or reject a theory, it has limitations, such as the possibility of missing important variables and the difficulty of generalizing findings beyond the study population.

Despite these limitations, deductive research is a type of research that can help inform policy and practice in various research fields.

### 5.2. *Hypothetic-deductive inquiry research*

Hypothetical-deductive inquiry (H-DiR) is a type of research that combines deductive and hypothetical reasoning.

In this type of research, researchers start from a hypothetical explanation of a phenomenon or observation and then use deductive reasoning to test the hypothesis, making predictions about what should happen if the hypothesis is correct.

The predictions are then tested using empirical data, and if the resulting data confirm the predictions, the hypothesis is considered to be supported. If the data do not support the predictions, the hypothesis is revised or rejected. This type of research is commonly used in the natural sciences, social sciences, and medicine to test hypotheses and establish causal relationships between variables.

The data thus collected are often quantitative, and the interpretation of the results is done with the help of statistical analysis.

Although, H-DiR can provide strong evidence to support or reject a hypothesis, it has limitations, such as the possibility of missing important variables and the difficulty of generalizing the results beyond the study population.

## 6. SOURCE OF INFORMATION

### 6.1. *Primary research*

Primary research (PR) is a type of research that involves collecting original data directly from sources.

This type of research involves conducting surveys, interviews, experiments, and observations to collect new information that has not been collected or analyzed previously studied.

PR can be qualitative or quantitative in nature, depending on the research topic and methodology.

The qualitative research methods used involve the collection of non-numerical data such as personal experiences, attitudes and behaviors, which are often used in the social sciences and humanities.

Quantitative research methods involve collecting numerical data and using statistical analysis to make inferences about a population and are commonly used in the natural sciences, social sciences, as well as the medical field.

PR is often expensive and time-consuming, but it can provide much more accurate and detailed information than secondary research, which involves analyzing existing data.

PR is important research and can help answer questions that cannot be answered with secondary research alone.



## 6.2. Secondary research

Secondary research (SR) is a type of research that involves analyzing existing data and information that has already been collected by other researchers.

This type of research involves examining published sources such as books, academic journals, reports, and databases to gather information about a specific topic or research topic.

SR can be qualitative or quantitative in nature, depending on the data sources and the research topic.

This type of research involves the analysis of non-numerical data such as case studies, literary analyses, interviews and is often used in the social sciences and humanities.

This type of research also involves the analysis of numerical data, such as statistics and surveys, and is commonly used in the natural sciences, social sciences, and medical fields.

SR is less expensive than primary research, but may have limitations such as outdated or incomplete data, biased sources, and limited data availability.

## 7. CONCLUSIONS

To research is equivalent to asking, given that the answers to these questions depend on the detailed knowledge of the field under research, respectively the detection of the limits of the research act in order to reduce the effect on the performance of the activity of scientific knowledge.

In general, the questions that the researcher asks are related to the object of the researched field and the limits of his knowledge, so that these elements produce, provoke and determine approaches and delimitations that are theoretical in terms of:

- scope of the addressed field;
- delimitation of the concepts to be used;
- the clear definition and characterization of the content of the concepts (historical approach);
- the delimitation of the techniques and tools to be used in the research;
- characterization and explanation of the way in which the obtained results will be used or have been used;
- comparing the results obtained, by applying the research tools, with the existing knowledge and with the structuring of the researcher's opinion.

## 8. REFERENCES

- [1] Aristotel, *Politica*, Ed. Antet, 1996.
- [2] Babbie E., *Practica cercetării sociale*, Ed. Polirom, 2010.
- [3] Daston L., Lunbeck E., *Histories of scientific observation*, University of Chicago Press, 2011.
- [4] Durkheim É., *Regulile metodei sociale*, Ed. Științifică, 1974.
- [5] Duță A., *Elemente de metodologia cercetării științifice în economie - Note de curs*, Biblioteca Catedrei de Economie, FEAA Timișoara, 2008.
- [6] Flyvbjerg B., *Case Study, The Sage Handbook of Qualitative Research*, 4<sup>th</sup> Edition, Sage Publications, London, 2011.
- [7] Hyman H. H., *Surveys in the Study of Political Psychology*, în J.N. Knutson, *Handbook of Political Psychology*, Jossey Bass, 1973.
- [8] Kuhrt A., *The ancient Near East c. 3000-330 B. C.*, Routledge History of the Ancient World. 2 vols. XXVIII, 381 pp.; XIX, 782 pp. London and New York: Routledge1995.
- [9] Lehnen R. G., *American Institutions, Political Opinion & Public Policy*, Dryden Press, 1976.
- [10] Nadeau R., *Vocabulaire technique et analytique de l'épistémologie*, Paris, PUF, 1999.
- [11] Ragin C. C., *Constructing Social Research*, Pine Forge Press, 1994.
- [12] Georgescu Ș., *Epistemologie*, Ed. Didactică și Pedagogică, București, 1970.
- [13] Trochim, W.M.K. *The Research Methods Knowledge Base*, 2<sup>nd</sup> Edition, Cornell University, New
- [14] Yin R. K., *Case Study Research: Design and Method*, Sage Publications, London, 1989.



**PUBLISHED SINCE : 2008**

**ISSN (Print): 1844-6116      ISSN (Online): 2501-8795**

**ON LINE SINCE : 2008**

<https://www.jmte.eu>

**PUBLISHED BY : EDITURA NAUTICA/CONSTANTA MARITIME UNIVERSITY**

**ISSN: 1844-6116**