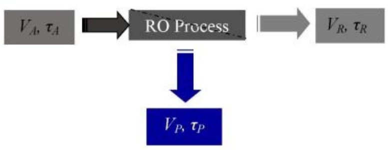
Global NEST Journal, Vol 24, No 4, pp 638-661

Empirical correlation with dimensionless parameters for following the kinetic separation performance via reverse osmosis desalination process of groundwater

Azizi A.[1]*, Abouda L.[2], Hanini S.[2], and Moussaoui M.[3]
[1]University Amar Telidji, Faculty of Technology, Highway Ghardaia post box G37 (M'kam) 03000, Laghouat, Algeria
[2]Department of Environment and Genius Processes, LBMPT Laboratory, University of Medea, Algeria
[3]University of Bouira, Bouira, Algeria
Received: 12/08/2022, Accepted: 27/09/2022, Available online: 16/10/2022
*to whom all correspondence should be addressed: e-mail: a.azizi@lagh-univ.dz
https://doi.org/10.30955/gnj.004421

Graphical abstract

Summary of dimensionless parameters inputs for following the performance of GWRO process.



Abstract

The present paper carries for novel modeling that are often used for evaluate the kinetic performance of groundwater reverse osmosis (GWRO) desalination system by empirical correlation with dimensionless parameters. About three hundred dimensionless empirical correlationshave been proposed and validated for the calculation of three cumulative dimensionless volumes: alimentation, permeate and rejection as a function of the dimensionless filtration time and vice versa. This correlation has obtained by inspiration of the models already proposed in the literature from four unitary operation processes: filtration, adsorption, drying and extraction. The experimental data consists of 2561 points taken during the lifetime of 66 organics RO membranes. The interpreting of regression and residual results is validated by four statistical criteria: reduced chi-Sqr, residual sum of residual, r-square (COD) and adj. R-square (R^2) and with two criteria in ANOVA analysis: sum of squares, mean square. Results show that 95 dimensionless empirical correlations (DEC) among 192 are highly capable to describe the separation kinetics on reverse osmosis desalination system curve with a least R^2 was around 0.970 in comparison to the best correlation (DEC 1) with R^2 of 0,998, 0,995 and 0,993 for alimentation, permeate and rejection, respectively, with negligible errors and perfect alignment of correlation with RO kinetic separation according to statistical criteria.

Keywords: dimensionless empirical correlation, reverse osmosis process, kinetic separation, desalination.

1. Introduction

Reverse-osmosis (RO) process is one of the most popular technologies for purifying seawater (Elimelech *et al.*, 2011), groundwater and brackish water (Pearson *et al.*, 2021; Ling *et al.*, 2021; Al-Obaidia *et al.*, 2018; Dimitriou *et al.*, 2017; Reverberi *et al.*, 2011; Hoek *et al.*, 2008), because this process presents by: high efficiency, simple, eco-friendly and nature-friendly technology for a wide range of issues in various fields (Qasim *et al.*, 2019; Aladwani *et al.*, 2021; Zhang *et al.*, 2022). Few models have been developed and analyzed the kinetic separation of solvent and solute fluxes through RO membranes (Najid *et al.*, 2022; Haluch *et al.*, 2017; Ibrar *et al.*, 2020; Xu *et al.*, 2020; Niewersch *et al.*, 2020; Chong *et al.*, 2022). These studies were begun in the early 1950's with Samuel T. Yuster who imagined the concept of utilizing the Gibb's adsorption equation as a road map to discover methods for making fresh water from brackish water and seawater (Gu *et al.*, 2021; Ghernaout, 2017; Haluch *et al.*, 2017; Choi and Kim, 2015; Bartman, 2011; Mehdizadeh, 1990; Soltanieh, 1981). Other classical approaches have been studied, such as removal, fouling and biofouling resistance, osmotic pressure models which are complicated, not good predictive of kinetic separation or treated smallest experimental data. Furthermore,they don't take into account the subtle coupling between hydrodynamics, mass transfer in the bulk solution and membrane transport. Moreover, the evaluation of rejection rate is not provided by such models: theoretical, empirical and semi-empirical model. Therefore, process design still heavily relies on time-consuming pilot experiments. This disadvantage is even more serious when scarce or costly materials and hazardous substances are used or treated (Jogdand and Chaudhuri, 2015; Al-

Obaidiet *al.*, 2018; Dimitriou *et al.*, 2017; Haluch *et al.*, 2017). For these purposes, dimensionless empirical correlations are very convenient as they combined rapidity, low cost and relativity easy implementation. The current work consists to developing a predictive dimensionless empirical correlation for applications ranging from reverse osmosis. The dimensionless empirical correlations do not use any experimental coefficients; it depends only on cumulative and maximum volume, instantly and maximum time of filtration. These inspired correlations have been obtained by analogy from the kinetic models of four unitary operations already proposed in the literature: filtration, adsorption, drying and extraction. The validation of tested correlations is made via statistical criteria and analysis of variance (ANOVA).

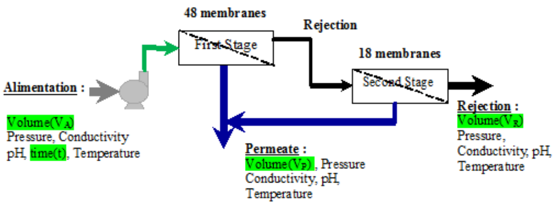


Figure 1. Simplified flowsheet of GWRO.

2. Materials and methods

2.1. Description of GWRO and plant data

The experiments were carried out at the Antibiotics Complex of Medea (Algeria). The groundwater (GWRO) was treated on three parts before using to an injectable ampule production. The practical operation of its desalination process effected during the life of the membrane (4 years). The water stream coming from the pre-treatment unit processed in a RO plant operating according to the scheme illustrated in Figure 1. Eleven modules constitute the RO plant depicted in Figure 1. They arranged in two stages in serial. The first and second stages contain six and five modules, respectively. Any module contains six membranes. Each of the pressure vessels of the RO plant containing a spiral wound polyamide membrane (ROGA® - HR 8.5") having a surface area of 38.6 m^2. The data consists of 2561×3 matrix. It collected every 2 hours for five seasons.

2.2. Modeling of separation on GWRO membrane

2.2.1. Empirical modeling

A dimensionless correlation was proposed for separation kinetic of GWRO desalination system filtration [$v = F(\tau)$], which are recorded in Table 1. These correlations are obtained by inspiration from the four processes models already proposed in the literature: adsorption, drying, extraction andfiltration.i.e., for separation on GWRO system, we keep the same empirical correlations of adsorption and extraction upstream and for drying and extraction downstream with:

$$V = \frac{v}{v_m} \tag{1}$$

and

$$\tau = \frac{t}{t_m} \tag{2}$$

V: cumulative dimensionless volume of the filtrate at time τ. v: cumulative volume of the filtrate at time $t(m^3)$. v_m: maximum cumulative volume of the filtrate at time $t(m^3)$. t: filtration time(hours). t_m: maximum filtration time(hours). τ: dimensionless filtration time.

Such as the modeling method that is often used to evaluate kinetic performance of GWRO desalination system by empirical correlation with dimensionless parameters was summarized in the Figure 2.

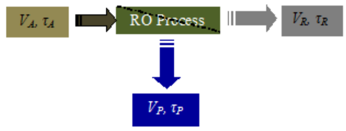


Figure 2. Summary of dimensionless parameters inputs for following the performance of GWRO process.

These proposed additional empirical correlations verify the initial condition:

$$\lim v_{t\to 0} = 0 \tag{3}$$

The ranges of variables used in this work are given in Table 1.

Table 1. The dimension and dimensionless variables range.

	Dimension variable				Dimensionless variable			
Ranges of variable	$10^{-6}v_P(m^3)$	$10^{-6}v_R(m^3)$	$10^{-6}v_A(m^3)$	$10^{-3}t$(hours)	V_P	V_R	V_A	τ
min	0	0	0	0	0	0	0	0
max	2144,07	1496,72	3603,78	36,37	1	1	1	1

2.2.2. Normalization of correlation constants

In order to limit the values of the correlation constants, normalization of this was done by the equation below:

$$a_n = 2 \times \frac{a_i - a_i(\min)}{a_i(\max) - a_i(\min)} - 1 \tag{4}$$

Such us, a_n: Normalized correlation constants; a_i: Correlation constants.

2.3. Regression analysis of results

Regression is commonly used to compute the best fit line. The performance of the regression analysis will produce an analysis report sheet outlining the regression results for each model.The performance an empirical correlation with dimensionless numbers for following the kinetic separationwere analyzed and improved via sets of statistical criteria as though reduced chi-Sqr, residual sum of residual, r-square (COD) and adj. R-square(R^2) and as well, with two ANOVA analysis criteria such as sum of squares and mean square. All these statistical criteria were calculated by Origin 2021b software (Alkarkhi and Wasin, 2020; Siegel and Wagner, 2022).

2.3.1. Residual Sum of Squares (RSS)

Residual Sum of Squares is the sum of the square of the vertical deviations from database point to the fitting regression line. It can be inferred that the database is perfect fit if the value of RSS is equal to zero. This statistic can help to decide if the fitted regression line is a good fit for our database (Williams and Quave, 2019; Siegel and Wagner, 2022).

2.3.2. Scale error with sqrt (Reduced Chi-Sqr)

The Reduced Chi-square value, which is also called Scale Error with square, is equal to the residual sum of square (RSS) divided by the degree of freedom. Typically, a Reduced Chi-square value close to 1 indicates a good fit result, and it implies that the difference between observed database and fitted data is consistent with the error variance. If the error variance is over-estimated, the Reduced Chi-square value will be much less than 1. For under-estimated error variance, it will be much greater than 1 (Wilcox, 2022; Tyagi *et al.*, 2022).

2.3.3. R-square (COD)

R-square, which is also known as the coefficient of determination (COD), is a statistical measure to qualify the linear regression. It is a percentage of the response variable variation that explained by the fitted regression line of correlation. Hence, R-square is always between 0 and 1. In general, the larger the R-square, the better the fitted line fits the databases (Wilcox, 2022; Siegel and Wagner, 2022).

2.3.4. Adj. R-Square

The Adj. R-square is a modified version of R-square, which is adjusted for the number of predictors in the fitted line. Thus, it can be used to compare with the fitted lines of the correlation with different numbers of predictors. If the number of predictors is greater than 1, Adj.-square is always smaller than R-square (Mostoufi and Constantinides, 2023; Siegel and Wagner, 2022).

3. Results and discussion

3.1. Regression analysis of dimensionless empirical correlations via GWRO kinetics

The optimizing DEC obtained from the best correlation fits are summarized in Tables 2–4. The average of these parameters for about 2561 data points covering the 95 kinetics are presented in Table 3.

Table 2. The dimensionless empirical correlations of the GWRO kinetics

DEC	Equations
1.	$V = \dfrac{1 - exp\left[-\left(a_1.\tau + a_2.\tau^{a_3}\right)\right]}{\left[1 + a_4.exp\left(-a_5.\tau + a_6.\tau^{a_7}\right)\right]^{a_8}}$
2.	$V = a_1 - a_1.exp\left(-a_2.\tau^{a_3}\right) - a_4.\tau^2 - a_5.\tau$
3.	$\tau = \left[a_1.V^{2.a_2} + a_3.V^{a_4}\right]^{1/a_5}$
4.	$\tau = a_1.V^{2a_2} + a_3.V^{a_2}$
5.	$V = \dfrac{a_1.\tau^{a_2}.\left[1 - a_3.exp(-a_4.\tau^{a_5})\right]}{a_6 + a_7.\tau^{a_8}}$
6.	$V = \left(a_1.\tau + a_2.\tau^{a_3}\right).\left[1 - \left(exp - \left(a_4 + a_5.\tau + a_6.\tau^{a_7}\right)\right)\right]$
7.	$V = 1 - \dfrac{1 - a_1.\tau^{a_2}.exp(-a_3.\tau^{a_2})}{\left[1 - a_1.\tau^{a_4}.exp(-a_5.\tau^{a_2})\right]^{a_6}}$
8.	$V = 1 - \left[1 - a_1.\tau^{a_2}.exp\left(-a_3.\tau^{a_4}\right)\right]^{a_5}$
9.	$V = \dfrac{1 - exp(-a_1.\tau^{a_2})}{\left(1 + \dfrac{a_3}{(1 + a_4)^{a_5}}.exp\left(-a_6.\tau^{a_7}\right)\right)^{a_5}}$
10.	$V = a_1.\tau^{a_2} + \left[1 - exp(-a_3.\tau^{a_4})\right]$
11.	$V = 1 + a_1.\tau^{a_2} - exp(-a_3.\tau^{a_4})$

12.	$V = 1 + a_1.\tau^{a_2} + a_3.\tau^{a_4} - exp\left[-a_5.\left(a_6.\tau^{a_7} + a_8.\tau^{a_9}\right)\right]$
13.	$V = \left(\dfrac{a_1.\tau^{a_2}}{a_3 + a_4.\tau^{a_5}}\right)^{a_6}$
14.	$V = a_1.\left[1 - exp\left(-a_2.\tau^{a_3}\right)\right]^{a_4}$
15.	$V = a_1.\left[1 - exp\left(-a_2.\tau^{a_3}\right)\right]^{a_4}$
16.	$V = a_1.\left[1 - exp\left(-a_2.\tau^{a_3}\right)\right]^{a_4}$
17.	$V = a_1.\left[1 - exp\left(-a_2.\tau^{a_3}\right)\right]^{a_4}$
18.	$V = \dfrac{a_1.\tau^{a_2}.\left[1 - exp\left(-a_3.\tau^{a_4}\right)\right]}{1 + a_5.\tau^{a_6}}$
19.	$V = \dfrac{a_1.\tau^{a_2}}{1 + a_3.\tau^{a_4}}$
20.	$V = \left[\dfrac{\left(a_1.\tau\right)^{a_2}}{1 + a_3.\tau^{a_4}}\right]^{a_5}$
21.	$V = \dfrac{a_1.\tau^{a_2}}{a_3 + a_4.\tau^{a_5}}$
22.	$V = \dfrac{a_1.\tau^{a_2}}{1 + a_3.\tau^{a_4}}$
23.	$V = \dfrac{a_1.\tau^{a_2}}{a_3 + a_4.\tau^{a_5}}$
24.	$V = a_1.\tau^{a_2}.exp\left(-a_3.\tau^{a_4}\right)$
25.	$V = a_1.\tau^{a_2}.exp\left(-a_3.\tau^{a_4}\right)$
26.	$V = \left(a_1 + a_2.\tau + a_3.\tau^{a_4}\right).\left[1 - exp\left(-\left(a_1.\tau + a_2.\tau^{a_5}\right)\right)\right]$
27.	$V = 1 - exp\left(-a_1.\tau^{a_2}\right) - a_3.\tau^{a_4}$
28.	$V = \dfrac{1 - exp\left[-\left(a_1.\tau + a_2.\tau^{a_3}\right)\right]}{1 + a_4.exp\left[-\left(a_5.a_2 + a_6.\tau^{a_7}\right)\right]}$
29.	$V = 1 - a_1.exp\left(-a_2.\tau^{a_3}\right) - \left(1 - a_1\right).exp\left(-a_4.\tau\right)$
30.	$V = a_1.\tau^{a_2}.\left[exp - \left(a_3.\tau^{a_2}\right)\right]$
31.	$V = 1 - a_1.a_2.exp\left(-a_3.\tau^{a_4}\right) - \left(1 - a_1.a_2\right).exp\left(-a_5.\tau^{a_6}\right)$
32.	$V = 1 - a_1.exp\left(-a_2.\tau^{a_3}\right) - \left(1 - a_1\right).exp\left(-a_2.a_4.\tau^{a_5}\right)$
33.	$V = 1 - a_1.exp\left(-a_2.\tau^{a_3}\right) - \left(1 - a_1\right).exp\left(-a_4.\tau^{a_5}\right)$
34.	$V = 1 - a_1^{a_2}.exp\left(-a_3.\tau^{a_4}\right) - \left(1 - a_1^{a_2}\right).exp\left(-a_5.\tau^{a_6}\right)$
35.	$V = a_1 * \left[1 - exp\left(-a_2.\tau^{a_3}\right)\right]$

36.	$V = 1 - a_1.a_2.\left(-a_3.\tau^{a_4}\right) - \left(1 - a_1.a_2\right).exp\left(-a_5.\tau^{a_4}\right)$
37.	$V = a_1.\tau^{a_2} + \left[1 - exp\left(-a_3.\tau^{a_2}\right)\right]$
38.	$V = \left[\dfrac{a_1.\tau}{a_2 + a_3.\tau}\right]^{a_4}$
39.	$V = 1 - exp(-a_1.\tau^{a_2} - a_3.\tau^{a_4})$
40.	$V = \left[\dfrac{a_1.\tau^{a_2}}{a_3 + a_1.\tau^{a_2}}\right]^{a_4}$
41.	$V = \left[1 - exp(-a_1.\tau^{a_2})\right]^{a_3}$
42.	$V = \left[1 - exp-\left(a_1.\tau + a_2\right)\right].\tau^{a_3 + a_4.\tau}$
43.	$V = a_1.\tau + a_2.\tau^{a_3} + 1 - \left[exp-(a_4.\tau^{a_5} + a_6.\tau^{a_7})\right]$
44.	$V = a_1.\tau^{a_2}.exp(-a_3.\tau^{a_4}) - a_5.\tau^{a_6}$
45.	$V = a_1.\tau.\left[1 - exp-(a_2.\tau + a_3.\tau^{a_4})\right]$
46.	$V = a_1.\tau + a_2.\tau^2 + a_3.\tau^{a_4}$
47.	$V = \dfrac{\left[1 + a_1.exp(-a_2.\tau)\right]^{a_3}}{1 + \left[1 - a_4.exp(-a_5.\tau)\right]^{a_6}}$
48.	$V = a_1.\tau - a_2.\tau^2$
49.	$V = a_1.\tau^{a_2} + a_3.\tau^{a_4}$
50.	$V = a_1.\tau^{a_2}$
51.	$V = \dfrac{a_1.\tau^{a_2}}{a_3 + \left(a_4 - 1\right).\tau^{a_5}}$
52.	$V = a_1.\tau^{a_2}$
53.	$V = 1 - exp\left(-a_1.\tau^{a_2}\right) - a_3.\tau$
54.	$V = \dfrac{(a_1.\tau)^{a_2}}{(1 + (a_1.\tau)^{a_2})}$
55.	$V = 1 - a_1^{a_2}.exp\left(-a_3.\tau\right) - \left(1 - a_4.a_1^{a_2}\right).exp\left(-a_5.\tau\right)$
56.	$V = \dfrac{a_1.\tau}{1 + a_2.\tau^{a_3}}$
57.	$V = 1 - a_1^{a_2}.exp\left(-a_3.\tau^{a_4}\right) - \left(1 - a_1^{a_2}\right).exp\left(-a_5.\tau^{a_4}\right)$
58.	$V = 1 - exp\left[-a_1.\tau^{a_2} - a_3.\tau\right]$
59.	$V = 1 - exp\left[-a_1.\left(a_2.\tau + a_3.\tau^{a_4}\right)\right]$
60.	$V = \left[1 - exp\left(-a_1.\tau^{a2}\right)\right]^{1/2}$
61.	$V = \left[1 - exp\left(-a_1.\tau^{a2}\right)\right]^{1/2}$
62.	$V = 2.a_1 - \left(a_1 - a_2\right).\left[exp\left(-a_3.a_4.\tau\right) - a_1.exp\left(-a_5.a_4.\tau\right) - a_2.exp\left(-a_6.a_4.\tau\right)\right]$

63.	$V = 1 - a_1.exp\left(-a_2.\tau^{a_3}\right) + a_4.\tau^{a_5}$
64.	$V = 1 - a_1.exp\left(-a_2.\tau^{a_3}\right) - \left(1 - a_1\right).exp\left(-a_4.a_5.\tau^{a_3}\right)$
65.	$V = 1 - a_1.(\tau^{a_2} - \tau^{a_3})$
66.	$V = 1 - a_1.exp\left(a_2.(1-\tau)^{a_3}\right) - \left(1 - a_4\right).exp\left(a_2.a_4.(1-\tau)^{a_5}\right)$
67.	$V = 1 - a_1.exp\left(-a_2.\tau^{a_3}\right)$
68.	$V = 1 - \left[a_1.exp\left(-a_2.\tau^{a_3}\right)\right]^{a_4}$
69.	$V = 1 - a_1.exp\left(-a_2.\tau\right) - \left(1 - a_1\right).\tau.exp\left(-a_3.\tau\right)$
70.	$V = 1 - a_1.exp\left(-a_2.(1-\tau)^{a_3}\right) - \left(1 - a_1\right).exp\left(-a_4.(1-\tau)\right)$
71.	$V = 1 - exp\left(-a_1.\tau^{a_2}\right)$
72.	$V = 1 - exp\left(-a_1.\tau^{a_2}\right)$
73.	$V = 1 - exp\left(a_1.\left(\frac{\tau}{a_2{}^2}\right)^{a_3}\right)$
74.	$V = \frac{a_1.\tau^{a_2}.\left(1 - exp(-a_3.\tau^{a_2})\right)}{1 + a_1.\tau^{a_2}}$
75.	$V = 1 - exp\left[-\left(\frac{\tau}{a_1}\right)^{a_2}\right]$
76.	$V = 1 - \frac{1 + a_1.\tau^{a_2}.ln(1 + a_3.\tau^{a_2})}{\left[1 + a_1.\tau^{a_4}.ln(1 + a_3.\tau^{a_4})\right]^{a_5}}$
77.	$V = a_1.\tau^{a_2}.\left[exp - \left(a_3.\tau + a_4\right)\right]^{a_4.\tau + a_5}$
78.	$V = 1 - \frac{a_1.\tau^{a_2}}{a_3 + a_4.\tau^{a_5}}$
79.	$V = \frac{a_1.\tau}{1 + a_2.\tau}$
80.	$V = 1 - a_1.\tau^{a_2}.\left[exp - (a_3.\tau + a_4)^{a_5.\tau + a_6}\right]$
81.	$V = \frac{a_1.\left[1 - exp\left(-a_2.\tau\right)\right]^{a_3}}{1 + \left(a_1 - 1\right).\left[1 - exp\left(-a_4.\tau\right)\right]^{a_5}}$
82.	$V = \frac{\left(a_1.\tau\right)^{a_2}}{1 + \left(a_1.\tau\right)^{a_2}}$
83.	$V = \frac{a_1.\tau^{a_2}}{1 + a_1.\tau^{a_2}}$
84.	$V = \frac{a_1.\tau^{a_2}}{a_3 + a_1.\tau^{a_2}}$
85.	$V = 1 - exp\left(-a_1.\tau^2 - a_2.\tau\right)$

86.	$V = 1 - a_1.\tau^{a_2}.exp\left(-a_3.\tau^{a_4}\right)$
87.	$V = a_1.v^{a_2}.\left[exp-(a_3.\tau + a_4)^{a_5\tau + a_6}\right]$
88.	$V = 1 - exp\left(-a_1.\tau\right) - \left(1 - a_2\right).\tau^{a_3}.exp\left(-a_4.\tau\right)$
89.	$V = 1 - a_1\, exp\left(-a_2.\tau\right) - \left(1 - a_1\right).exp\left(-a_3.\tau\right)$
90.	$V = 1 - \left(\frac{1}{1 + (a_1 - 1).a_2.\tau}\right)^{\frac{1}{a_1 - 1}}$
91.	$V = 2.a_1 - a_1.exp\left(-a_2.a_3.\tau\right) - a_1.exp\left(-a_4.a_3.\tau\right)$
92.	$V = 1 - a_1.\tau^{a_2}.exp\left(-a_3.\tau^{a_2}\right)$
93.	$V = 1 - exp\left(-a_1.\tau^{a_2}\right) - a_3.\tau^{a_2}$
94.	$V = a_1.\tau^{a_2}.\left[exp-\left(a_3.\tau^{a_4} + a_5\right)\right]^{a_5.\tau + a_6}$
95.	$V = a_1 - a_2.exp\left[-a_3.\left(a_4 + a_5.\tau\right)^{a_6}\right]$

Table 3. Statistic value for dimensionless empirical correlations of V_A, V_P and V_R

DEC	V_A				V_P				V_R			
	COD	R²	Reduced Chi-Sqr	RSS	COD	R²	Reduced Chi-Sqr	RSS	COD	R²	Reduced Chi-Sqr	RSS
1	0,99861	0,9986	1,17E-04	0,29884	0,9957	0,99568	1,81E-05	0,04626	0,99374	0,99372	2,69E-05	0,06854
2	0,99857	0,99857	1,20E-04	0,30632	0,62188	0,62129	0,00159	4,06381	0,6504	0,64985	0,0015	3,82783
3	0,99799	0,99799	1,35E-04	0,34533	0,93029	0,93018	0,00468	11,93783	0,97173	0,97168	0,0019	4,8415
4	0,99794	0,99794	1,38E-04	0,35392	0,85666	0,85655	0,00961	24,548	0,90582	0,90575	0,00631	16,12802
5	0,99751	0,9975	2,09E-04	0,5341	0,98444	0,98439	6,56E-05	0,16727	0,98669	0,98665	5,71E-05	0,14573
6	0,99749	0,99749	2,10E-04	0,53677	0,95293	0,9528	1,98E-04	0,50586	0,96214	0,96204	1,63E-04	0,41452
7	0,99749	0,99749	2,10E-04	0,53705	0,74242	0,74192	0,00108	2,7683	0,8639	0,86363	1,49021	0,8639
8	0,99748	0,99748	2,11E-04	0,53904	0,97833	0,9783	9,12E-05	0,23287	0,98238	0,98236	0,19288	0,98238
9	0,99747	0,99747	2,12E-04	0,5419	0,98222	0,98218	7,49E-05	0,19108	0,98484	0,98481	6,50E-05	0,16594
10	0,99747	0,99747	2,12E-04	0,54146	0,97591	0,97588	1,01E-04	0,25893	0,97957	0,97954	8,76E-05	0,22373
11	0,99747	0,99747	2,12E-04	0,54146	0,97591	0,97588	1,01E-04	0,25893	0,97957	0,97954	8,76E-05	0,22373
12	0,99747	0,99747	2,12E-04	0,54135	0,55051	0,5491	0,0019	4,83086	0,56428	0,56292	0,00187	4,77073
13	0,99747	0,99747	2,12E-04	0,54155	0,98592	0,98589	5,93E-05	0,15136	0,68702	0,68641	0,00134	3,42684
14	0,99747	0,99747	2,12E-04	0,54151	0,53542	0,53487	0,00195	4,99304	0,56358	0,56306	0,00187	4,77847
15	0,99747	0,99747	2,12E-04	0,54151	0,53542	0,53487	0,00195	4,99304	0,56358	0,56306	0,00187	4,77847
16	0,99747	0,99747	2,12E-04	0,54151	0,53542	0,53487	0,00195	4,99304	0,56358	0,56306	0,00187	4,77847
17	0,99747	0,99747	2,12E-04	0,54151	0,53542	0,53487	0,00195	4,99304	0,56358	0,56306	0,00187	4,77847
18	0,99747	0,99747	2,12E-04	0,54152	0,97585	0,9758	1,02E-04	0,25953	0,97989	0,97985	8,63E-05	0,22021
19	0,99747	0,99747	2,12E-04	0,54155	0,97585	0,97583	1,02E-04	0,2595	0,97989	0,97987	8,62E-05	0,2202
20	0,99747	0,99747	2,12E-04	0,54159	0,53547	0,53475	0,00196	4,99243	0,56363	0,56295	0,00187	4,77788
21	0,99747	0,99747	2,12E-04	0,5415	0,65611	0,65557	0,00145	3,69591	0,68707	0,68657	0,00134	3,42638
22	0,99747	0,99747	2,12E-04	0,54155	0,97585	0,97583	1,02E-04	0,2595	0,97989	0,97987	8,62E-05	0,2202
23	0,99747	0,99747	2,12E-04	0,5415	0,65611	0,65557	0,00145	3,69591	0,68707	0,68657	0,00134	3,42638
24 25	0,99747	0,99747	2,12E-04	0,54144	0,90925	0,90915	3,82E-04	0,9753	0,92541	0,92532	3,20E-04	0,81672
26	0,99747	0,99747	2,12E-04	0,54144	0,90925	0,90915	3,82E-04	0,9753	0,92541	0,92532	3,20E-04	0,81672
27	0,99747	0,99747	2,12E-04	0,54164	0,50533	0,50456	0,00208	5,3164	0,53218	0,53145	0,00201	5,12224
28	0,99746	0,99746	2,13E-04	0,54429	0,96767	0,96763	1,36E-04	0,34749	0,97957	0,97954	8,76E-05	0,22373

29	0,99745	0,99745	2,14E-04	0,54566	0,9236	0,92342	3,22E-04	0,82109	0,98485	0,98481	6,50E-05	0,16591
30	0,99745	0,99745	2,13E-04	0,54558	0,9812	0,98118	7,91E-05	0,20201	0,98413	0,98411	6,81E-05	0,17381
31	0,99746	0,99745	2,13E-04	0,54513	0,88815	0,88807	4,70E-04	1,20206	0,90605	0,90597	4,03E-04	1,02869
32	0,99746	0,99745	2,13E-04	0,54511	0,75831	0,75784	0,00102	2,59749	0,78626	0,78584	9,17E-04	2,34033
33	0,99746	0,99745	2,13E-04	0,54484	0,98151	0,98148	7,78E-05	0,19874	0,98437	0,98434	6,70E-05	0,17115
34	0,99746	0,99745	2,13E-04	0,54484	0,98116	0,98113	7,93E-05	0,2025	0,98404	0,98402	6,84E-05	0,17473
35	0,99746	0,99745	2,13E-04	0,54512	0,98116	0,98112	7,94E-05	0,20251	0,98404	0,98401	6,85E-05	0,17473
36	0,99745	0,99745	2,13E-04	0,54585	0,66491	0,66465	0,00141	3,60129	0,28173	0,28116	0,00308	7,86451
37	0,99744	0,99744	2,15E-04	0,54828	0,97348	0,97344	1,12E-04	0,28505	0,97761	0,97758	9,60E-05	0,24512
38	0,99744	0,99744	2,14E-04	0,54825	0,97324	0,97322	1,13E-04	0,28763	0,97761	0,9776	9,59E-05	0,24512
39	0,99741	0,9974	2,17E-04	0,55566	0,93071	0,93063	2,92E-04	0,74469	0,92925	0,92916	3,03E-04	0,77469
40	0,99735	0,99735	2,22E-04	0,56795	0,96767	0,96763	1,36E-04	0,34749	0,97315	0,97312	1,15E-04	0,29402
41	0,99734	0,99734	2,23E-04	0,56911	0,9818	0,98177	7,66E-05	0,19565	0,98568	0,98566	6,14E-05	0,15678
42	0,99734	0,99733	2,23E-04	0,57102	0,97121	0,97119	1,21E-04	0,30942	0,97737	0,97736	9,70E-05	0,24774
43	0,99733	0,99732	2,24E-04	0,57261	0,66227	0,66187	0,00142	3,62974	0,69239	0,69203	0,00132	3,36808
44	0,99747	0,99747	2,12E-04	0,54138	0,10485	0,10274	0,00377	9,62051	0,11094	0,10884	0,00382	9,73452
45	0,9973	0,9973	2,26E-04	0,57814	0,94133	0,94121	2,47E-04	0,63056	0,95305	0,95296	2,01E-04	0,51407
46	0,9973	0,99729	2,27E-04	0,57957	0,89996	0,8998	4,21E-04	1,07519	0,91648	0,91634	3,58E-04	0,91452
47	0,9973	0,99729	2,27E-04	0,57944	0,89996	0,89984	4,21E-04	1,07518	0,91648	0,91638	3,58E-04	0,91452
48	0,9973	0,99729	2,27E-04	0,57882	0,11658	0,1145	0,00372	9,49444	0,13224	0,1302	0,00372	9,50126
49	0,99693	0,99693	2,57E-04	0,65692	-11,98906	-11,99414	0,05462	139,59824	-11,49731	-11,5022	0,05353	136,83527
50	0,99687	0,99687	2,62E-04	0,67069	0,53547	0,53493	0,00195	4,99243	0,56363	0,56312	0,00187	4,77787
51	0,99687	0,99687	2,62E-04	0,67069	0,53547	0,53529	0,00195	4,99243	0,56363	0,56346	0,00187	4,77787
52	0,99687	0,99687	2,62E-04	0,6707	0,97585	0,97581	1,02E-04	0,25958	0,97988	0,97985	8,63E-05	0,22026
53	0,99687	0,99687	2,62E-04	0,67069	0,53547	0,53529	0,00195	4,99243	0,56363	0,56346	0,00187	4,77787
54	0,99669	0,99668	2,78E-04	0,70985	0,63312	0,63283	0,00154	3,943	0,60245	0,60214	0,0017	4,35286
55	0,9966	0,9966	2,84E-04	0,72767	0,95324	0,95322	1,97E-04	0,50254	0,96424	0,96422	1,53E-04	0,39158
56	0,99564	0,99563	3,66E-04	0,93422	0,98794	0,98793	5,07E-05	0,12956	0,98962	0,98961	4,45E-05	0,11363
57	0,99529	0,99529	3,94E-04	1,00841	0,97245	0,97244	1,16E-04	0,29613	0,97721	0,9772	9,76E-05	0,2495
58	0,99481	0,9948	4,35E-04	1,11287	0,96767	0,96762	1,36E-04	0,34749	0,97315	0,9731	1,15E-04	0,29402
59	0,99418	0,99417	4,88E-04	1,24796	0,97583	0,97581	1,02E-04	0,25978	0,98107	0,98105	8,11E-05	0,20728
60	0,99418	0,99417	4,88E-04	1,24796	0,97604	0,97601	1,01E-04	0,25755	0,98107	0,98105	8,11E-05	0,20722
61	0,9941	0,9941	4,94E-04	1,26442	0,96137	0,96135	1,62E-04	0,41521	0,9653	0,96529	1,49E-04	0,37989
62	0,9941	0,9941	4,94E-04	1,26442	0,96137	0,96135	1,62E-04	0,41521	0,9653	0,96529	1,49E-04	0,37989
63	0,99372	0,99371	5,26E-04	1,34478	0,97926	0,97922	8,73E-05	0,22288	0,98015	0,98011	8,52E-05	0,21739
64	0,99246	0,99245	6,32E-04	1,6151	0,44676	0,44568	0,00233	5,94584	0,48634	0,48534	0,0022	5,62414
65	0,99229	0,99228	6,46E-04	1,65202	0,98192	0,98189	7,61E-05	0,19429	0,97314	0,9731	1,15E-04	0,29404
66	0,99222	0,99221	6,52E-04	1,66758	0,44273	0,44229	0,00234	5,9892	0,47259	0,47218	0,00226	5,77472
67	0,99182	0,9918	6,86E-04	1,75326	0,89486	0,89466	4,43E-04	1,12993	0,89702	0,89682	1,12751	0,89702
68	0,99165	0,99164	7,00E-04	1,78983	0,96773	0,96771	1,36E-04	0,34677	0,97322	0,9732	1,15E-04	0,2932
69	0,99165	0,99163	7,00E-04	1,78983	0,96773	0,96768	1,36E-04	0,34677	0,97322	0,97318	1,15E-04	0,2932
70	0,99131	0,9913	7,28E-04	1,86148	0,97771	0,97768	9,38E-05	0,23961	0,97403	0,974	1,11E-04	0,2843
71	0,99095	0,99094	7,59E-04	1,93938	0,85878	0,85856	5,95E-04	1,51777	0,85134	0,85111	6,38E-04	1,62765
72	0,98942	0,98942	8,86E-04	2,2669	0,96767	0,96765	1,36E-04	0,34749	0,97315	0,97314	1,15E-04	0,29402
73	0,98942	0,98941	8,86E-04	2,2669	0,96767	0,96764	1,36E-04	0,34749	0,97315	0,97313	1,15E-04	0,29402
74	0,98942	0,98941	8,86E-04	2,26702	0,96767	0,96764	1,36E-04	0,34749	0,97315	0,97313	1,15E-04	0,29402
75	0,98942	0,98941	8,86E-04	2,26689	0,97781	0,97779	9,33E-05	0,23851	0,55185	0,5515	0,00192	4,90688

76	0,98942	0,98941	8,86E-04	2,26689	0,96767	0,96764	1,36E-04	0,34749	0,97315	0,97313	1,15E-04	0,29402
77	0,98886	0,98884	9,34E-04	2,38766	0,97977	0,97974	8,52E-05	0,2174	0,98321	0,98319	7,20E-05	0,1838
78	0,98848	0,98846	9,66E-04	2,46894	0,87347	0,87322	5,33E-04	1,35989	0,87063	0,87038	5,55E-04	1,41649
79	0,98547	0,98545	0,00122	3,113	0,83464	0,83438	6,96E-04	1,77721	0,85079	0,85056	6,40E-04	1,63371
80	0,98103	0,98102	0,00159	4,06468	0,95739	0,95738	1,79E-04	0,4579	0,96789	0,96788	1,38E-04	0,35154
81	0,98104	0,981	0,00159	4,06347	-0,07376	-0,07586	0,00452	11,54006	0,96328	0,96321	1,58E-04	0,40201
82	0,97462	0,97458	0,00213	5,43757	0,98418	0,98416	6,66E-05	0,17	0,98652	0,9865	5,78E-05	0,14763
83	0,97397	0,97396	0,00218	5,57792	0,07573	0,07536	0,00389	9,93352	0,07285	0,07248	0,00397	10,15155
84	0,97397	0,97396	0,00218	5,57804	0,97535	0,97534	1,04E-04	0,26491	0,97829	0,97828	9,30E-05	0,23769
85	0,97397	0,97395	0,00218	5,57795	0,97535	0,97535	1,04E-04	0,2649	0,97829	0,97827	9,30E-05	0,23769
86	0,97233	0,97232	0,00232	5,92875	0,94867	0,94865	2,16E-04	0,55162	0,93942	0,9394	2,60E-04	0,6633
87	0,75643	0,75614	0,02041	52,19179	0,96765	0,96761	1,36E-04	0,34768	0,97147	0,97143	1,22E-04	0,31242
88	0,97062	0,97055	0,00247	6,2958	0,93696	0,93681	2,66E-04	0,67751	0,94952	0,9494	2,17E-04	0,5527
89	0,96505	0,96501	0,00293	7,48858	0,98231	0,98229	7,44E-05	0,19012	0,98505	0,98504	6,41E-05	0,16365
90	0,93121	0,93116	0,00576	14,73953	0,98098	0,98096	8,00E-05	0,20445	0,93368	0,93363	2,84E-04	0,72613
91	0,90466	0,90463	0,00798	20,42827	0,97725	0,97724	9,56E-05	0,24448	0,98169	0,98168	7,84E-05	0,20047
92	0,83059	0,83039	0,0142	36,30168	0,97178	0,97175	1,19E-04	0,3033	0,97201	0,97198	1,20E-04	0,30648
93	0,75643	0,75614	0,02041	52,19179	0,96765	0,96761	1,36E-04	0,34768	0,97147	0,97143	1,22E-04	0,31242
94	0,34804	0,34753	0,05461	139,69978	0,97324	0,97322	1,13E-04	0,28763	0,97761	0,9776	9,59E-05	0,24512
95	-1,41905	-1,42474	0,20295	518,34669	0,96723	0,96715	1,38E-04	0,35219	0,97389	0,97383	1,12E-04	0,28583

Table 4.ANOVAvalues for dimensionless empirical correlations concerning V_A, V_P, V_R

DEC	V_A				V_p				V_r			
	Sum of Squares-Regression	Mean Square-Regression	Sum of Squares Residual	Mean Square Residual	Sum of Squares-Regression	Mean Square-Regression	Sum of Squares-Residual	Mean Square-Residual	Sum of Squares-Regression	Mean Square-Regression	Sum of Squares Residual	Mean Square Residual
1	519,04785	64,88098	0,29884	1,17E-04	2479,43397	309,92925	0,04626	1,81E-05	2474,44991	309,30624	0,06854	2,69E-05
2	519,04037	103,80807	0,30632	1,20E-04	2475,41643	495,08329	4,06381	0,00159	2470,69063	494,13813	3,82783	0,0015
3	859,34167	171,86833	0,34533	1,35E-04	844,75345	168,95069	11,93783	0,00468	851,84978	170,36996	4,8415	0,0019
4	859,33308	286,44436	0,35392	1,38E-04	832,14328	277,38109	24,548	0,00961	840,56326	280,18775	16,12802	0,00631
5	518,81259	64,85157	0,5341	2,09E-04	2479,31297	309,91412	0,16727	6,56E-05	2474,37273	309,29659	0,14573	5,71E-05
6	518,80992	64,85124	0,53677	2,10E-04	2478,97438	309,8718	0,50586	1,98E-04	2474,10394	309,26299	0,41452	1,63E-04
7	518,80964	86,46827	0,53705	2,10E-04	2476,71194	412,78532	2,7683	0,00108	2473,02825	412,17137	1,49021	5,84E-04
8	518,80765	103,76153	0,53904	2,11E-04	2479,24737	495,84947	0,23287	9,12E-05	2474,32558	494,86512	0,19288	7,56E-05
9	518,80479	74,11497	0,5419	0,5419	2479,28916	354,18417	0,19108	7,49E-05	2474,35252	353,47893	0,16594	6,50E-05
10	518,80523	129,70131	0,54146	2,12E-04	2479,22131	619,80533	0,25893	1,01E-04	2474,29473	618,57368	0,22373	8,76E-05
11	518,80523	129,70131	0,54146	2,12E-04	2479,22131	619,80533	0,25893	1,01E-04	2474,29473	618,57368	0,22373	8,76E-05
12	518,80534	57,64504	0,54135	2,12E-04	2474,64938	274,96104	4,83086	0,0019	2469,74773	274,41641	4,77073	0,00187
13	518,80514	86,46752	0,54155	2,12E-04	2479,32888	413,22148	0,15136	5,93E-05	2471,09162	411,8486	3,42684	0,00134
14	518,80518	129,7013	0,54151	2,12E-04	2474,4872	618,6218	4,99304	0,00195	2469,73999	617,435	4,77847	0,00187
15	518,80518	129,7013	0,54151	2,12E-04	2474,4872	618,6218	4,99304	0,00195	2469,73999	617,435	4,77847	0,00187
16	518,80518	129,7013	0,54151	2,12E-04	2474,4872	618,6218	4,99304	0,00195	2469,73999	617,435	4,77847	0,00187
17	518,80518	129,7013	0,54151	2,12E-04	2474,4872	618,6218	4,99304	0,00195	2469,73999	617,435	4,77847	0,00187
18	518,80517	86,46753	0,54152	2,12E-04	2479,22071	413,20345	0,25953	1,02E-04	2474,29825	412,38304	0,22021	8,63E-05
19	518,80514	129,70128	0,54155	2,12E-04	2479,22074	619,80518	0,2595	1,02E-04	2474,29826	618,57457	0,2202	8,62E-05
20	518,8051	103,76102	0,54159	2,12E-04	2474,48781	494,89756	4,99243	0,00196	2469,74058	493,94812	4,77788	0,00187
21	518,80519	103,76104	0,5415	2,12E-04	2475,78433	495,15687	3,69591	0,00145	2471,09208	494,21842	3,42638	0,00134
22	518,80514	129,70128	0,54155	2,12E-04	2479,22074	619,80518	0,2595	1,02E-04	2474,29826	618,57457	0,2202	8,62E-05
23	518,80519	103,76104	0,5415	2,12E-04	2475,78433	495,15687	3,69591	0,00145	2471,09208	494,21842	3,42638	0,00134
24	518,80525	129,70131	0,54144	2,12E-04	2478,50494	619,62623	0,9753	3,82E-04	2473,70173	618,42543	0,81672	3,20E-04
25	518,80525	129,70131	0,54144	2,12E-04	2478,50494	619,62623	0,9753	3,82E-04	2473,70173	618,42543	0,81672	3,20E-04
26	518,80505	103,76101	0,54164	2,12E-04	2474,16384	494,83277	5,3164	0,00208	2469,39622	493,87924	5,12224	0,00201
27	518,8024	129,7006	0,54429	2,13E-04	2479,13275	619,78319	0,34749	1,36E-04	2474,29473	618,57368	0,22373	8,76E-05
28	518,80103	74,11443	0,54566	2,14E-04	2478,65915	354,09416	0,82109	3,22E-04	2474,35255	353,47894	0,16591	6,50E-05
29	518,80111	129,70028	0,54558	2,13E-04	2479,27823	619,81956	0,20201	7,91E-05	2474,34465	618,58616	0,17381	6,81E-05

30	518,80156	172,93385	0,54513	2,13E-04	2478,27817	826,09272	1,20206	4,70E-04	2473,48977	824,49659	1,02869	4,03E-04
31	518,80158	86,46693	0,54511	2,13E-04	2476,88275	412,81379	2,59749	0,00102	2472,17813	412,02969	2,34033	9,17E-04
32	518,80185	103,76037	0,54484	2,13E-04	2479,2815	495,8563	0,19874	7,78E-05	2474,34731	494,86946	0,17115	6,70E-05
33	518,80185	103,76037	0,54484	2,13E-04	2479,27774	495,85555	0,2025	7,93E-05	2474,34373	494,86875	0,17473	6,84E-05
34	518,80157	86,46693	0,54512	2,13E-04	2479,27773	413,21296	0,20251	7,94E-05	2474,34373	412,39062	0,17473	6,85E-05
35	518,80084	172,93361	0,54585	2,13E-04	2475,87895	825,29298	3,60129	0,00141	2466,65395	822,21798	7,86451	0,00308
36	518,79841	103,75968	0,54828	2,15E-04	2479,19519	495,83904	0,28505	1,12E-04	2474,27334	494,85467	0,24512	9,60E-05
37	518,79844	172,93281	0,54825	2,14E-04	2479,1926	826,39753	0,28763	1,13E-04	2474,27334	824,75778	0,24512	9,59E-05
38	518,79103	129,69776	0,55566	2,17E-04	2478,73555	619,68389	0,74469	2,92E-04	2473,74377	618,43594	0,77469	3,03E-04
39	518,77874	129,69468	0,56795	2,22E-04	2479,13275	619,78319	0,34749	1,36E-04	2474,22444	618,55611	0,29402	1,15E-04
40	518,77758	129,6944	0,56911	2,23E-04	2479,28459	619,82115	0,19565	7,66E-05	2474,36167	618,59042	0,15678	6,14E-05
41	518,77567	172,92522	0,57102	2,23E-04	2479,17082	826,39027	0,30942	1,21E-04	2474,27072	824,75691	0,24774	9,70E-05
42	518,77408	129,69352	0,57261	2,24E-04	2475,8505	618,96263	3,62974	0,00142	2471,15038	617,78759	3,36808	0,00132
43	518,80531	74,11504	0,54138	2,12E-04	2469,85973	352,8371	9,62051	0,00377	2464,78394	352,11199	9,73452	0,00382
44	518,76855	86,46143	0,57814	2,26E-04	2478,84968	413,14161	0,63056	2,47E-04	2474,00439	412,33407	0,51407	2,01E-04
45	518,76712	103,75342	0,57957	2,27E-04	2478,40505	495,68101	1,07519	4,21E-04	2473,60394	494,72079	0,91452	3,58E-04
46	518,76725	129,69181	0,57944	2,27E-04	2478,40506	619,60126	1,07518	4,21E-04	2473,60394	618,40098	0,91452	3,58E-04
47	518,76787	74,1097	0,57882	2,27E-04	2469,9858	352,85511	9,49444	0,00372	2465,0172	352,14531	9,50126	0,00372
48	518,68977	259,34488	0,65692	2,57E-04	2339,882	1169,941	139,59824	0,05462	2337,68319	1168,8416	136,83527	0,05353
49	518,676	129,669	0,67069	2,62E-04	2474,48781	618,62195	4,99243	0,00195	2469,74058	617,43515	4,77787	0,00187
50	518,67599	259,338	0,67069	2,62E-04	2474,48781	1237,24391	4,99243	0,00195	2469,74058	1234,87029	4,77787	0,00187
51	518,67599	103,7352	0,6707	2,62E-04	2479,22066	495,84413	0,25958	1,02E-04	2474,2982	494,85964	0,22026	8,63E-05
52	518,67599	259,338	0,67069	2,62E-04	2474,48781	1237,24391	4,99243	0,00195	2469,74058	1234,87029	4,77787	0,00187
53	518,63684	172,87895	0,70985	2,78E-04	2475,53724	825,17908	3,943	0,00154	2470,1656	823,38853	4,35286	0,0017
54	518,61902	259,30951	0,72767	2,84E-04	2478,9777	1239,48885	0,50254	1,97E-04	2474,12688	1237,06344	0,39158	1,53E-04
55	518,41247	103,68249	0,93422	3,66E-04	2479,35068	495,87014	0,12956	5,07E-05	2474,40483	494,88097	0,11363	4,45E-05
56	518,33828	259,16914	1,00841	3,94E-04	2479,18411	1239,59205	0,29613	1,16E-04	2474,26896	1237,13448	0,2495	9,76E-05
57	518,23382	103,64676	1,11287	4,35E-04	2479,13275	495,82655	0,34749	1,36E-04	2474,22444	494,84489	0,29402	1,15E-04
58	518,09873	172,69958	1,24796	4,88E-04	2479,22046	826,40682	0,25978	1,02E-04	2474,31118	824,77039	0,20728	8,11E-05
59	518,09873	129,52468	1,24796	4,88E-04	2479,22269	619,80567	0,25755	1,01E-04	2474,31124	618,57781	0,20722	8,11E-05
60	518,08227	259,04114	1,26442	4,94E-04	2479,06503	1239,53251	0,41521	1,62E-04	2474,13857	1237,06928	0,37989	1,49E-04
61	518,08227	259,04114	1,26442	4,94E-04	2479,06503	1239,53251	0,41521	1,62E-04	2474,13857	1237,06928	0,37989	1,49E-04
62	518,00191	86,33365	1,34478	5,26E-04	2479,25736	413,20956	0,22288	8,73E-05	2474,30107	412,38351	0,21739	8,52E-05
63	517,73159	86,2886	1,6151	6,32E-04	2473,5344	412,25573	5,94584	0,00233	2468,89432	411,48239	5,62414	0,0022
64	517,69467	103,53893	1,65202	6,46E-04	2479,28595	495,85719	0,19429	7,61E-05	2474,22441	494,84488	0,29404	1,15E-04
65	517,67911	172,5597	1,66758	6,52E-04	2473,49104	824,49701	5,9892	0,00234	2468,74374	822,91458	5,77472	0,00226
66	517,59343	86,26557	1,75326	6,86E-04	2478,35031	413,05838	1,12993	4,43E-04	2473,39095	412,23183	1,12751	4,42E-04
67	517,55686	172,51895	1,78983	7,00E-04	2479,13347	826,37782	0,34677	1,36E-04	2474,22525	824,74175	0,2932	1,15E-04
68	517,55686	103,51137	1,78983	7,00E-04	2479,13347	495,82669	0,34677	1,36E-04	2474,22525	494,84505	0,2932	1,15E-04
69	517,48521	129,3713	1,86148	7,28E-04	2479,24063	619,81016	0,23961	9,38E-05	2474,23416	618,55854	0,2843	1,11E-04
70	517,40731	103,48146	1,93938	7,59E-04	2477,96247	495,59249	1,51777	5,95E-04	2472,89081	494,57816	1,62765	6,38E-04
71	517,07979	258,5399	2,2669	8,86E-04	2479,13275	1239,56637	0,34749	1,36E-04	2474,22444	1237,11222	0,29402	1,15E-04
72	517,07979	172,35993	2,2669	8,86E-04	2479,13275	826,37758	0,34749	1,36E-04	2474,22444	824,74148	0,29402	1,15E-04
73	517,07967	172,35989	2,26702	8,86E-04	2479,13275	826,37758	0,34749	1,36E-04	2474,22444	824,74148	0,29402	1,15E-04
74	517,0798	172,35993	2,26689	8,86E-04	2479,24173	826,41391	0,23851	9,33E-05	2469,61158	823,20386	4,90688	0,00192
75	517,0798	172,35993	2,26689	8,86E-04	2479,13275	826,37758	0,34749	1,36E-04	2474,22444	824,74148	0,29402	1,15E-04
76	516,95903	103,39181	2,38766	9,34E-04	2479,26284	495,85257	0,2174	8,52E-05	2474,33466	494,86693	0,1838	7,20E-05
77	516,87775	86,14629	2,46894	9,66E-04	2478,12035	413,02006	1,35989	5,33E-04	2473,10197	412,18366	1,41649	5,55E-04
78	516,23369	103,24674	3,113	0,00122	2477,70302	495,5406	1,77721	6,96E-04	2472,88475	494,57695	1,63371	6,40E-04
79	515,28201	257,641	4,06468	0,00159	2479,02234	1239,51117	0,4579	1,79E-04	2474,16692	1237,08346	0,35154	1,38E-04
80	515,28322	85,88054	4,06347	0,00159	2467,94018	411,32336	11,54006	0,00452	2474,11645	412,35274	0,40201	1,58E-04
81	513,90912	102,78182	5,43757	0,00213	2479,31024	495,86205	0,17	6,66E-05	2474,37083	494,87417	0,14763	5,78E-05
82	513,76877	256,88439	5,57792	0,00218	2469,54672	1234,77336	9,93352	0,00389	2464,36691	1232,18345	10,15155	0,00397
83	513,76865	256,88432	5,57804	0,00218	2479,21533	1239,60767	0,26491	1,04E-04	2474,28077	1237,14039	0,23769	9,30E-05
84	513,76874	171,25625	5,57795	0,00218	2479,21534	826,40511	0,2649	1,04E-04	2474,28077	824,76026	0,23769	9,30E-05
85	513,41794	256,70897	5,92875	0,00232	2478,92862	1239,46431	0,55162	2,16E-04	2473,85516	1236,92758	0,6633	2,60E-04
86	467,1549	116,78873	52,19179	0,02041	2479,13256	619,78314	0,34768	1,36E-04	2474,20604	618,55151	0,31242	1,22E-04
87	513,05089	73,29298	6,2958	0,00247	2478,80273	354,11468	0,67751	2,66E-04	2473,96576	353,42368	0,5527	2,17E-04
88	511,85811	127,96453	7,48858	0,00293	2479,29012	619,82253	0,19012	7,44E-05	2474,35481	618,5887	0,16365	6,41E-05

89	504,60716	168,20239	14,73953	0,00576	2479,27579	826,42526	0,20445	8,00E-05	2473,79233	824,59744	0,72613	2,84E-04
90	498,91842	249,45921	20,42827	0,00798	2479,23576	1239,61788	0,24448	9,56E-05	2474,31799	1237,15899	0,20047	7,84E-05
91	483,04501	120,76125	36,30168	0,0142	2479,17694	619,79424	0,3033	1,19E-04	2474,21198	618,553	0,30648	1,20E-04
92	467,1549	116,78873	52,19179	0,02041	2479,13256	619,78314	0,34768	1,36E-04	2474,20604	618,55151	0,31242	1,22E-04
93	379,64691	126,54897	139,69978	0,05461	2479,1926	826,39753	0,28763	1,13E-04	2474,27334	824,75778	0,24512	9,59E-05
94	1	0,14286	518,34669	0,20295	2479,12805	354,16115	0,35219	1,38E-04	2474,23263	353,4618	0,28583	1,12E-04
95	0	0	519,34669	0,20327	10,56481	2,11296	0,18256	7,15E-05	2471,94528	411,99088	2,57318	0,00101

Table 5. Estimated model parameters *(a_i)* of 95 equations proposed in this work for V_A.

DEC	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	a_9	a_{10}
1	1,02521	3,15094	11,22294	8,68E+13	47,1946	0,03322	-3,4179	0,05526	---	---
2	0,05385	3,53E+09	46,46943	-0,9535	-0,00985	---	---	---	---	---
3	0,02552	0,22593	0,97361	0,02682	0,07023	---	---	---	---	---
4	0,44527	0,35435	0,53726	---	---	---	---	---	---	---
5	1,26489	1,30891	1,03202	0,95055	0,95596	0,73483	0,03323	30,81155	---	---
6	11,22445	24,7755	2,90634	0,49054	-0,66815	0,71501	0,90637	---	---	---
7	1,3882	1,38343	0,3239	1,16035	0,78195	0,55423	---	---	---	---
8	1,33023	1,92063	0,28535	-0,58338	1,1311	---	---	---	---	---
9	1,19839	2,20442	0,07862	-0,99981	-0,11362	-6,73569	0,77656	---	---	---
10	1,60835	2,28501	-0,47	2,68787	---	---	---	---	---	---
11	1,60835	2,28501	-0,47	2,68787	---	---	---	---	---	---
12	0,13009	2,23624	0,13009	2,23422	1,6279	0,26525	5,00182	0,57991	2,18165	---
13	1,09608	-0,41501	0,23396	0,84516	-4,68045	0,50639	---	---	---	---
14	1,55944	0,53464	4,36411	0,49539	---	---	---	---	---	---
15	1,55944	0,53464	4,36411	0,49539	---	---	---	---	---	---
16	1,55944	0,53464	4,36411	0,49539	---	---	---	---	---	---
17	1,55944	0,53464	4,36411	0,49539	---	---	---	---	---	---
18	2,77371	-1,76773	0,41013	3,92643	-0,07404	2,90398	---	---	---	---
19	8,85738	-2,52073	7,79457	-4,67597	---	---	---	---	---	---
20	1,77019	2,01238	2,07251	-4,96836	0,30926	---	---	---	---	---
21	1,03709	-2,27939	0,12166	0,90756	-4,44072	---	---	---	---	---
22	8,85738	-2,52073	7,79457	-4,67597	---	---	---	---	---	---
23	1,03709	-2,27939	0,12166	0,90756	-4,44072	---	---	---	---	---
24	1,14491	2,16274	0,12802	4,19631	---	---	---	---	---	---
25	1,14491	2,16274	0,12802	4,19631	---	---	---	---	---	---
26	-0,03463	0,94099	0,79478	-0,46828	2,24286	---	---	---	---	---
27	0,88341	2,6037	-0,42431	1,83767	---	---	---	---	---	---
28	1,0973	0,64854	1,13829	-0,38215	1,79606	-1,42851	0,19807	---	---	---
29	2,43656	0,52749	2,29834	-0,00948	---	---	---	---	---	---
30	1,27304	2,25138	0,22883	---	---	---	---	---	---	---
31	-11,14475	-5,98751	0,24943	2,33499	0,23409	2,34297	---	---	---	---
32	1,78225	0,64655	2,40844	-0,29283	1,61342	---	---	---	---	---
33	1,77627	0,64819	2,4095	-0,19204	1,61387	---	---	---	---	---
34	2,0046	4,07717	0,27255	2,32384	0,21108	2,35588	---	---	---	---
35	2,61153	0,49104	2,25726	---	---	---	---	---	---	---
36	0,01834	0,01834	1265,03034	2,28075	0,88933	---	---	---	---	---
37	0,42856	2,27566	0,88286	---	---	---	---	---	---	---
38	3,62946	2,58692	1,01616	2,55039	---	---	---	---	---	---
39	1,69582	2,50341	2,35781	13,33978	---	---	---	---	---	---
40	23,93459	35,09321	9,15043	0,05853	---	---	---	---	---	---

41	1,80736	18,66985	0,11095	---	---	---	---	---	---	---
42	9,89E+07	5,85E+07	2,25787	-0,58071	---	---	---	---	---	---
43	-0,00629	1,62885	2,26461	-0,23928	2,61288	-0,23928	2,61329	---	---	---
44	1,77955	1,59739	-0,36302	0,01308	1,53178	1,3896	---	---	---	---
45	12,18648	-1,06085	1,15934	0,98165	---	---	---	---	---	---
46	-0,17324	-25,31128	26,51063	1,99023	---	---	---	---	---	---
47	0,00622	18,10413	0,15652	-1,05341	0,4154	6,47515	---	---	---	---
48	-0,01779	-1,05824	---	---	---	---	---	---	---	---
49	0,51922	2,01255	0,51922	2,01388	---	---	---	---	---	---
50	1,03843	2,01314	---	---	---	---	---	---	---	---
51	0,71598	2,01246	1,28508	0,4044	8,19E-04	---	---	---	---	---
52	1,03843	2,01314	---	---	---	---	---	---	---	---
53	1,53475	3,24692	-0,19526	---	---	---	---	---	---	---
54	1,46269	-1,96442	---	---	---	---	---	---	---	---
55	1,08672	46,59699	-0,73567	0,9991	-0,75808	---	---	---	---	---
56	-8,30E+35	-0,92662	---	---	---	---	---	---	---	---
57	0,07451	-8,09647	0,93333	2,71855	0,93333	---	---	---	---	---
58	2,38975	4,00029	0,24901	---	---	---	---	---	---	---
59	0,79142	0,31469	3,01966	4,00061	---	---	---	---	---	---
60	1,93749	4,94341	---	---	---	---	---	---	---	---
61	1,93749	4,94341	---	---	---	---	---	---	---	---
62	3,36089	4,35406	3,27784	0,93104	0,29601	0,30031	---	---	---	---
63	1,01222	-1,69E+15	8,52E+15	1,04501	1,94978	---	---	---	---	---
64	1,08525	1,96183	2,94445	2,37E-06	2,37E-06	---	---	---	---	---
65	1,03879	2,01396	64429,78407	---	---	---	---	---	---	---
66	0,08937	2,07543	0,35951	1,06056	0,35187	---	---	---	---	---
67	0,96871	2,40706	3,31342	---	---	---	---	---	---	---
68	0,96265	1,94741	3,31346	0,83529	---	---	---	---	---	---
69	1,09154	0,66528	-3,02797	---	---	---	---	---	---	---
70	2,46104	0,31193	0,05234	0,91866	---	---	---	---	---	---
71	2,31296	3,03642	---	---	---	---	---	---	---	---
72	2,8247	3,03637	---	---	---	---	---	---	---	---
73	0,45093	3,03095	---	---	---	---	---	---	---	---
74	1,92E+44	3,03603	2,31279	---	---	---	---	---	---	---
75	0,6479	3,03522	---	---	---	---	---	---	---	---
76	0,66743	1,54166	0,08461	1,5467	44,32724	---	---	---	---	---
77	0,25099	1,99577	1,20E+05	-4,04E+04	-2,04E+04	---	---	---	---	---
78	0,73216	-0,03851	0,83068	5,36124	5,29118	---	---	---	---	---
79	0,3622	-0,67459	---	---	---	---	---	---	---	---
80	0,89084	-0,0581	1,80364	-0,42399	1,80364	-0,42399	---	---	---	---
81	-4,44251	4,12434	10,28025	10,39576	6,60766		---	---	---	---
82	1,51616	4,12649	---	---	---	---	---	---	---	---
83	5,58203	4,13203	---	---	---	---	---	---	---	---
84	-367,9288	4,12873	-66,00968	---	---	---	---	---	---	---
85	2,38215	-0,52407	---	---	---	---	---	---	---	---
86	9,33E+08	-4,0027	21,74897	-0,1358	---	---	---	---	---	---
87	0,42918	1,11955	-0,18921	0,18921	1,32518	-0,46482	---	---	---	---

88	3,02105	-33,70161	2,03861	5,64076	---	---	---	---	---	---
89	78,07395	3,21628	3,27893	---	---	---	---	---	---	---
90	-1,00197	0,5003	---	---	---	---	---	---	---	---
91	1846,07783	0,00182	0,11134	0,00182	---	---	---	---	---	---
92	9,33E+08	-4,0027	21,74897	-0,1358	---	---	---	---	---	---
93	46,48518	-0,19539	0,5522	---	---	---	---	---	---	---
94	1	1	1	1	1	1	---	---	---	---
95	2,01487	2,50454	-0,73645	-0,50831	-8,22496	6,87359	---	---	---	---

Table 6. Normalized correlation constants *(a_n)* of V_A.

DEC	a_1	a_2	a_3	a_4	a_5	a_6
1	-0.999999991354167	0.999995822493937	-0.999999999999982	1,00E+00	1	-0.00525082884619910
2	-0.999999991354167	1,00E+00	-0.999999999999974	-0.999999999069146	0.995382794469027	---
3	-0.999999991354167	0.999995822493933	-0.999999999999984	-0.999999999069124	0.995390627328406	---
4	-0.999999991354167	0.999995822493933	-0.999999999999984	---	---	---
5	-0.999999991354167	0.999995822493935	-0.999999999999984	-0.999999999069103	0.995477263174284	0.0978567565661077
6	-0.999999991354167	0.999995822493962	-0.999999999999984	-0.999999999069113	0.995318404217662	0.0949440381857085
7	-0.999999991354167	0.999995822493935	-0.999999999999985	-0.999999999069098	0.995460242746455	0.0713160431705424
8	-0.999999991354167	0.999995822493935	-0.999999999999985	-0.999999999069138	0.995494394130724	---
9	-0.999999991354167	0.999995822493936	-0.999999999999985	-0.999999999069148	0.995372644421353	-1
10	-0.999999991354167	0.999995822493936	-0.999999999999985	-0.999999999069063	---	---
11	-0.999999991354167	0.999995822493936	-0.999999999999985	-0.999999999069063	---	---
12	-0.999999991354167	0.999995822493936	-0.999999999999985	-0.999999999069073	0.995542987594005	0.0288479625667191
13	-0.999999991354167	0.999995822493932	-0.999999999999985	-0.999999999069105	0.994925949401391	0.0642855463330903
14	-0.999999991354167	0.999995822493934	-0.999999999999984	-0.999999999069113	---	---
15	-0.999999991354167	0.999995822493934	-0.999999999999984	-0.999999999069113	---	---
16	-0.999999991354167	0.999995822493934	-0.999999999999984	-0.999999999069113	---	---
17	-0.999999991354167	0.999995822493934	-0.999999999999984	-0.999999999069113	---	---
18	-0.999999991354167	0.999995822493931	-0.999999999999985	-0.999999999069034	0.995376515857095	0.416631886477462
19	-0.999999991354167	0.999995822493930	-0.999999999999983	-0.999999999069232	---	---
20	-0.999999991354167	0.999995822493935	-0.999999999999984	-0.999999999069239	0.995414007552899	---
21	-0.999999991354167	0.999995822493930	-0.999999999999985	-0.999999999069104	0.994949398094935	---
22	-0.999999991354167	0.999995822493930	-0.999999999999983	-0.999999999069232	---	---
23	-0.999999991354167	0.999995822493930	-0.999999999999985	-0.999999999069104	0.994949398094935	---
24	-0.999999991354167	0.999995822493936	-0.999999999999985	-0.999999999069028	---	---
25	-0.999999991354167	0.999995822493936	-0.999999999999985	-0.999999999069028	---	---
26	-0.999999991354167	0.999995822493934	-0.999999999999984	-0.999999999069135	0.995603138633013	---
27	-0.999999991354167	0.999995822493936	-0.999999999999985	-0.999999999069082	---	---
28	-0.999999991354167	0.999995822493934	-0.999999999999984	-0.999999999069133	0.995559435816198	-0.220064544193374
29	-0.999999991354167	0.999995822493934	-0.999999999999984	-0.999999999069125	---	---
30	-0.999999991354167	0.999995822493936	-0.999999999999985	---	---	---
31	-0.999999991354167	0.999995822493926	-0.999999999999985	-0.999999999069071	0.995406654955003	0.334186672623386
32	-0.999999991354167	0.999995822493934	-0.999999999999984	-0.999999999069131	0.995541571262789	---
33	-0.999999991354167	0.999995822493934	-0.999999999999984	-0.999999999069129	0.995541615278607	---
34	-0.999999991354167	0.999995822493938	-0.999999999999985	-0.999999999069071	0.995404404279500	0.336083907451386
35	-0.999999991354167	0.999995822493934	-0.999999999999984	---	---	---
36	-0.999999991354167	0.999995822493933	-0.999999999999688	-0.999999999069072	0.995470745898804	---
37	-0.999999991354167	0.999995822493936	-0.999999999999984	---	---	---
38	-0.999999991354167	0.999995822493936	-0.999999999999984	-0.999999999069066	---	---
39	-0.999999991354167	0.999995822493936	-0.999999999999984	-0.999999999068817	---	---
40	-0.999999991354167	0.999995822493974	-0.999999999999982	-0.999999999069123	---	---
41	-0.999999991354167	0.999995822493955	-0.999999999999985	---	---	---
42	-0.999999991354167	0.999995891724558	-0.999999999999984	-0.999999999069138	---	---
43	-0.999999991354167	0.999995822493935	-0.999999999999984	-0.999999999069130	0.995639331373117	-0.0452970326130405
44	-0.999999991354167	0.999995822493935	-0.999999999999985	-0.999999999069124	0.995533585815240	0.194080803686896
45	-0.999999991354167	0.999995822493932	-0.999999999999984	-0.999999999069102	---	---
46	-0.999999991354167	0.999995822493903	-0.999999999999978	-0.999999999069079	---	---

47	-0.999999991354167	0.999995822493954	-0.999999999999985	-0.999999999069149	0.995424389417217	0.941445836958311
48	-0.999999991354167	0.999995822493932	---	---	---	---
49	-0.999999991354167	0.999995822493935	-0.999999999999984	-0.999999999069078	---	---
50	-0.999999991354167	0.999995822493935	---	---	---	---
51	-0.999999991354167	0.999995822493935	-0.999999999999984	-0.999999999069115	0.995383838035170	---
52	-0.999999991354167	0.999995822493935	---	---	---	---
53	-0.999999991354167	0.999995822493937	-0.999999999999985	---	---	---
54	-0.999999991354167	0.999995822493931	---	---	---	---
55	-0.999999991354167	0.999995822493988	-0.999999999999985	-0.999999999069101	0.995309607900930	---
56	-1,00E+00	0.999995822493932	---	---	---	---
57	-0.999999991354167	0.999995822493923	-0.999999999999984	-0.999999999069062	0.995475049667694	---
58	-0.999999991354167	0.999995822493938	-0.999999999999985	---	---	---
59	-0.999999991354167	0.999995822493933	-0.999999999999984	-0.999999999069032	---	---
60	-0.999999991354167	0.999995822493939	---	---	---	---
61	-0.999999991354167	0.999995822493939	---	---	---	---
62	-0.999999991354167	0.999995822493938	-0.999999999999984	-0.999999999069103	0.995412711531586	0.0340003291871429
63	-0.999999991354167	-1,00E+00	1,00E+00	-0.999999999069100	0.995574471619691	---
64	-0.999999991354167	0.999995822493935	-0.999999999999984	-0.999999999069124	0.995383758158198	---
65	-0.999999991354167	0.999995822493935	-0.999999999984860	---	---	---
66	-0.999999991354167	0.999995822493935	-0.999999999999985	-0.999999999069100	0.995418175361817	---
67	-0.999999991354167	0.999995822493936	-0.999999999999984	---	---	---
68	-0.999999991354167	0.999995822493935	-0.999999999999984	-0.999999999069105	---	---
69	-0.999999991354167	0.999995822493934	-0.999999999999985	---	---	---
70	-0.999999991354167	0.999995822493933	-0.999999999999985	-0.999999999069103	---	---
71	-0.999999991354167	0.999995822493937	---	---	---	---
72	-0.999999991354167	0.999995822493937	---	---	---	---
73	-0.999999991354167	0.999995822493937	---	---	---	---
74	1,00E+00	0.999995822493937	-0.999999999999984	---	---	---
75	-0.999999991354167	0.999995822493937	---	---	---	---
76	-0.999999991354167	0.999995822493935	-0.999999999999985	-0.999999999069089	0.999719535119013	---
77	-0.999999991354167	0.999995822493935	-0.999999999971816	-1,00E+00	-1,00E+00	---
78	-0.999999991354167	0.999995822493933	-0.999999999999984	-0.999999999069001	0.995901303741688	---
79	-0.999999991354167	0.999995822493932	---	---	---	---
80	-0.999999991354167	0.999995822493933	-0.999999999999984	-0.999999999069134	0.995560177238202	-0.0724417456323920
81	-0.999999991354167	0.999995822493938	-0.999999999999982	-0.999999999068885	0.996030072506866	---
82	-0.999999991354167	0.999995822493938	---	---	---	---
83	-0.999999991354167	0.999995822493938	---	---	---	---
84	-0.999999991354167	0.999995822493938	-1	---	---	---
85	-0.999999991354167	0.999995822493932	---	---	---	---
86	-0.999999991354167	0.999995822493928	-0.999999999999979	-0.999999999069128	---	---
87	-0.999999991354167	0.999995822493934	-0.999999999999985	-0.999999999069120	0.995513377664044	-0.0784420630628512
88	-0.999999991354167	0.999995822493893	-0.999999999999984	-0.999999999068995	---	---
89	-0.999999991354167	0.999995822493937	-0.999999999999984	---	---	---
90	-0.999999991354167	0.999995822493934	---	---	---	---
91	-0.999999991354167	0.999995822493933	-0.999999999999985	-0.999999999069124	---	---
92	-0.999999991354167	0.999995822493928	-0.999999999999979	-0.999999999069128	---	---
93	-0.999999991354167	0.999995822493933	-0.999999999999984	---	---	---
94	-0.999999991354167	0.999995822493934	-0.999999999999984	-0.999999999069101	0.995481570855691	0.136825754191258
95	-0.999999991354167	0.999995822493936	-0.999999999999985	-0.999999999069136	0.994579250495322	1

Table 7. Estimated model parameters *(a_i)* of 95 equations proposed in this work for V_P

DEC	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	a_9	a_{10}
1	0,90701	6,26229	0,3386	212,9391	208,24451	-10641,04919	3,90E+13	0,19898	---	---
2	0,71452	0,16435	-1,68177	1,07328	-1,9273	---	---	---	---	---
3	5267,46569	1476,77484	3,73E-05	345,34186	11,27481	---	---	---	---	---
4	1,04852	132,15195	0,63623	---	---	---	---	---	---	---
5	0,55713	-0,86442	-3580,8315	5,99062	-0,15286	5,54351	0,04969	-1,5505	---	---
6	-6,07587	8,64379	0,37844	0,69251	-7,17942	7,17584	1,04471	---	---	---
7	1,27709	0,05012	0,22682	-8,23285	77,07524	22311,3115	---	---	---	---

8	0,11619	0,91114	2,40078	0,46855	483,51346	---	---	---	---	---
9	39,57239	0,88076	-0,03104	1,25358	-1,60656	4,9799	0,50675	---	---	---
10	-0,0062	-0,08303	16,76157	0,69592	---	---	---	---	---	---
11	-0,0062	-0,08303	16,76157	0,69592	---	---	---	---	---	---
12	0,23044	0,04336	0,23044	0,04336	3,00106	0,14032	0,09299	0,14032	0,10567	---
13	2,06281	0,05061	2,05963	3,49E-04	-2,66814	0,21132	---	---	---	---
14	0,28936	1,05E-04	-0,39805	-0,13858	---	---	---	---	---	---
15	0,28936	1,05E-04	-0,39805	-0,13858	---	---	---	---	---	---
16	0,28936	1,05E-04	-0,39805	-0,13858	---	---	---	---	---	---
17	0,28936	1,05E-04	-0,39805	-0,13858	---	---	---	---	---	---
18	1,80099	-0,00679	0,80859	2,09E-04	0,00342	-1,29555	---	---	---	---
19	306,27726	1,30149	306,71095	1,30774	---	---	---	---	---	---
20	0,98581	-6,36563	31,27241	-0,00221	-0,00867	---	---	---	---	---
21	0,8348	-3,38062	0,09813	0,77125	-3,46329					
22	306,27726	1,30149	306,71095	1,30774	---	---	---	---	---	---
23	0,8348	-3,38062	0,09813	0,77125	-3,46329	---	---	---	---	---
24	46,06941	0,53732	3,85314	0,15798	---	---	---	---	---	---
25	46,06941	0,53732	3,85314	0,15798	---	---	---	---	---	---
26	0,81112	1,02832	-0,6699	1,68674	-0,8533	---	---	---	---	---
27	13,5085	0,6441	-1,36E-06	1069744,045	---	---	---	---	---	---
28	3,75922	1,8176	-0,57275	0,98043	11,05933	4,91584	-5,27305	---	---	---
29	3,54738	13,21061	0,8445	16,40852	---	---	---	---	---	---
30	3,4669	0,30732	1,26815	---	---	---	---	---	---	---
31	1625,34597	246,06362	1,03013	0,54689	1,03013	0,5469	---	---	---	---
32	1,43473	12,07708	0,73814	3,0664	1,44549	---	---	---	---	---
33	17,68894	14,29437	0,90169	14,84411	0,9288	---	---	---	---	---
34	10,71585	1,23941	14,30378	0,90239	14,81638	0,9277	---	---	---	---
35	0,98458	38,14367	-172,48909	---	---	---	---	---	---	---
36	0,16388	0,16454	-0,28265	0,68794	15,44312	---	---	---	---	---
37	-0,00743	0,66413	14,56378	---	---	---	---	---	---	---
38	0,40964	-0,00596	0,41473	-0,35299	---	---	---	---	---	---
39	7,07128	0,64405	6,43519	0,64409	---	---	---	---	---	---
40	0,26898	1,64601	7,90E-04	0,40169	---	---	---	---	---	---
41	10,25755	0,37496	4,0485	---	---	---	---	---	---	---
42	-1,38846	4,81179	0,06805	-0,21381	---	---	---	---	---	---
43	-3,75035	4,13468	1,0903	0,50003	-1,42081	0,49968	-1,46794	---	---	---
44	15,94403	0,48938	-0,58326	0,20835	27,55809	0,62869	---	---	---	---
45	1,46395	0,42835	1,27103	-0,75588	---	---	---	---	---	---
46	-1,46891	0,62782	1,86175	0,24429	---	---	---	---	---	---
47	0,68792	-53,70252	0,68092	0,72522	-10,4247	0,51072	---	---	---	---
48	3,83515	3,17467	---	---	---	---	---	---	---	---
49	0,51487	0,05514	0,51487	0,05514	---	---	---	---	---	---
50	1,02974	0,05514	---	---	---	---	---	---	---	---
51	1,17111	1,31983	0,00354	2,1728	1,32528	---	---	---	---	---
52	1,02974	0,05514	---	---	---	---	---	---	---	---
53	14,07946	-172,5444	0,01128	---	---	---	---	---	---	---
54	126,40175	0,99748	---	---	---	---	---	---	---	---
55	1,13071	-1,43429	51,84724	1,11368	5,51363	---	---	---	---	---
56	87,16636	1,02605	---	---	---	---	---	---	---	---
57	1,44E+11	-24,23326	1,59445	0,6441	13,50851	---	---	---	---	---
58	73,11221	0,8683	-68,4413	---	---	---	---	---	---	---
59	5,01114	-10,47879	11,4297	0,84015	---	---	---	---	---	---
60	23,41877	0,95439	---	---	---	---	---	---	---	---
61	23,41877	0,95439	---	---	---	---	---	---	---	---
62	0,49638	1,44356	1,08444	24,74384	3,07021	1,08445	---	---	---	---
63	1,18485	-1,59E+14	3,09E+15	1,21501	0,04687	---	---	---	---	---
64	0,93432	35,34633	0,87269	2,17341	2,1633	---	---	---	---	---
65	1,02983	0,0552	1651,03186	---	---	---	---	---	---	---
66	9,41084	3,5349	-16,74588	0,62713	-2,54644	---	---	---	---	---

67	0,98512	13,95874	0,65733	---	---	---	---	---	---	---
68	0,9761	22,58514	0,65729	0,61911	---	---	---	---	---	---
69	0,85659	37,0282	3,954	---	---	---	---	---	---	---
70	90626,27337	4,48656	-3,31275	28941,89962	---	---	---	---	---	---
71	13,50851	0,6441	---	---	---	---	---	---	---	---
72	12,57032	0,64407	---	---	---	---	---	---	---	---
73	1,21597	0,64459	---	---	---	---	---	---	---	---
74	228,9838	0,72924	21,28457	---	---	---	---	---	---	---
75	0,10447	0,64435	---	---	---	---	---	---	---	---
76	2537,93595	0,88588	0,00842	0,48992	2,8816	---	---	---	---	---
77	0,45266	0,13161	0,65288	-0,00373	0,65669	---	---	---	---	---
78	0,1247	-18,54545	7,42E+16	2,63859	-18,15078	---	---	---	---	---
79	119,19887	117,72534	---	---	---	---	---	---	---	---
80	-24,90594	39,48381	5,73496	20,57044	5,73496	20,57044	---	---	---	---
81	1,57405	13,40336	0,60671	20,46533	3,13156	---	---	---	---	---
82	1,13E-32	-0,05586	---	---	---	---	---	---	---	---
83	504,20715	1,41972	---	---	---	---	---	---	---	---
84	118,93954	1,41876	0,2366	---	---	---	---	---	---	---
85	-43,48794	47,98653	---	---	---	---	---	---	---	---
86	0,95638	-1,45E-09	15,33985	0,69237	---	---	---	---	---	---
87	1,62263	0,33552	129,99757	2,48945	-0,02398	0,19619	---	---	---	---
88	13,49305	7,87853	0,6147	20,39681	---	---	---	---	---	---
89	0,07998	6,2917	58,45335	---	---	---	---	---	---	---
90	1,54576	74,97195	---	---	---	---	---	---	---	---
91	0,49627	24,28382	4,04404	7,24547	---	---	---	---	---	---
92	0,95638	-1,45E-09	15,33985	0,69237	---	---	---	---	---	---
93	14,56378	0,66413	0,00743	---	---	---	---	---	---	---
94	0,02881	-0,46266	0,17099	-0,19581	0,6282	12,49095	---	---	---	---
95	0,99465	26711,35807	8,20292	3,33173	104,38148	0,18811	---	---	---	---

Table 8. Normalized correlation constants *(a_n)* of V_P.

DEC	a_1	a_2	a_3	a_4	a_5	a_6
1	-0.999999991354167	0.999995822493937	-0.999999999999982	1	1	-0.00525082884619910
2	-0.999999991354167	1	-0.999999999999974	-0.999999999069146	0.995382794469027	-0.0101327917421054
3	-0.999999991354167	0.999995822493933	-0.999999999999984	-0.999999999069124	0.995390627328406	---
4	-0.999999991354167	0.999995822493933	-0.999999999999984	-0.999999999069124	0.995383757926381	---
5	-0.999999991354167	0.999995822493935	-0.999999999999984	---	---	---
6	-0.999999991354167	0.999995822493962	-0.999999999999984	-0.999999999069113	0.995318404217662	0.0949440381857085
7	-0.999999991354167	0.999995822493935	-0.999999999999985	-0.999999999069098	0.995460242746455	0.0713160431705424
8	-0.999999991354167	0.999995822493935	-0.999999999999985	-0.999999999069138	0.995494394130724	-0.0101327917421054
9	-0.999999991354167	0.999995822493936	-0.999999999999985	-0.999999999069148	0.995372644421353	---
10	-0.999999991354167	0.999995822493936	-0.999999999999985	-0.999999999069063	0.995383757926381	-0.0101327917421054
11	-0.999999991354167	0.999995822493936	-0.999999999999985	-0.999999999069063	---	---
12	-0.999999991354167	0.999995822493936	-0.999999999999985	-0.999999999069073	---	---
13	-0.999999991354167	0.999995822493932	-0.999999999999985	-0.999999999069105	0.994925949401391	0.0642855463330903
14	-0.999999991354167	0.999995822493934	-0.999999999999984	-0.999999999069113	0.995383757926381	-0.0101327917421054
15	-0.999999991354167	0.999995822493934	-0.999999999999984	-0.999999999069113	---	---
16	-0.999999991354167	0.999995822493934	-0.999999999999984	-0.999999999069113	---	---
17	-0.999999991354167	0.999995822493934	-0.999999999999984	-0.999999999069113	---	---
18	-0.999999991354167	0.999995822493931	-0.999999999999985	-0.999999999069034	---	---
19	-0.999999991354167	0.999995822493930	-0.999999999999983	-0.999999999069232	0.995383757926381	-0.0101327917421054
20	-0.999999991354167	0.999995822493935	-0.999999999999984	-0.999999999069239	---	---
21	-0.999999991354167	0.999995822493930	-0.999999999999985	-0.999999999069104	0.994949398094935	---
22	-0.999999991354167	0.999995822493930	-0.999999999999983	-0.999999999069232	0.995383757926381	---

23	-0.999999991354167	0.999995822493930	-0.999999999999985	-0.999999999069104	---	---
24	-0.999999991354167	0.999995822493936	-0.999999999999985	-0.999999999069028	0.995383757926381	---
25	-0.999999991354167	0.999995822493936	-0.999999999999985	-0.999999999069028	---	---
26	-0.999999991354167	0.999995822493934	-0.999999999999984	-0.999999999069135	---	---
27	-0.999999991354167	0.999995822493936	-0.999999999999985	-0.999999999069082	0.995383757926381	---
28	-0.999999991354167	0.999995822493934	-0.999999999999984	-0.999999999069133	---	---
29	-0.999999991354167	0.999995822493934	-0.999999999999984	-0.999999999069125	0.995383757926381	-0.0101327917421054
30	-0.999999991354167	0.999995822493936	-0.999999999999985	-0.999999999069124	---	---
31	-0.999999991354167	0.999995822493926	-0.999999999999985	---	---	---
32	-0.999999991354167	0.999995822493934	-0.999999999999984	-0.999999999069131	0.995541571262789	-0.0101327917421054
33	-0.999999991354167	0.999995822493934	-0.999999999999984	-0.999999999069129	0.995541615278607	---
34	-0.999999991354167	0.999995822493938	-0.999999999999985	-0.999999999069071	0.995404404279500	---
35	-0.999999991354167	0.999995822493934	-0.999999999999984	-0.999999999069124	0.995383757926381	-0.0101327917421054
36	-0.999999991354167	0.999995822493933	-0.999999999999688	---	---	---
37	-0.999999991354167	0.999995822493936	-0.999999999999984	-0.999999999069124	0.995383757926381	---
38	-0.999999991354167	0.999995822493936	-0.999999999999984	----	---	---
39	-0.999999991354167	0.999995822493936	-0.999999999999984	-0.999999999068817	---	---
40	-0.999999991354167	0.999995822493974	-0.999999999999982	-0.999999999069123	---	---
41	-0.999999991354167	0.999995822493955	-0.999999999999985	-0.999999999069124	---	---
42	-0.999999991354167	0.999995891724558	-0.999999999999984	---	---	---
43	-0.999999991354167	0.999995822493935	-0.999999999999984	-0.999999999069130	---	---
44	-0.999999991354167	0.999995822493935	-0.999999999999985	-0.999999999069124	0.995533585815240	0.194080803686896
45	-0.999999991354167	0.999995822493932	-0.999999999999984	-0.999999999069102	0.995383757926381	-0.0101327917421054
46	-0.999999991354167	0.999995822493903	-0.999999999999978	-0.999999999069079	---	---
47	-0.999999991354167	0.999995822493954	-0.999999999999985	-0.999999999069149	---	---
48	-0.999999991354167	0.999995822493932	-0.999999999999985	-0.999999999069124	0.995383757926381	-0.0101327917421054
49	-0.999999991354167	0.999995822493935	---	---	---	---
50	-0.999999991354167	0.999995822493935	-0.999999999999985	-0.999999999069124	---	---
51	-0.999999991354167	0.999995822493935	---	---	---	---
52	-0.999999991354167	0.999995822493935	-0.999999999999985	-0.999999999069124	0.995383757926381	---
53	-0.999999991354167	0.999995822493937	---	---	---	---
54	-0.999999991354167	0.999995822493931	-0.999999999999985	---	---	---
55	-0.999999991354167	0.999995822493988	---	---	---	---
56	-1	0.999995822493932	-0.999999999999985	-0.999999999069124	0.995383757926381	---
57	-0.999999991354167	0.999995822493923	---	---	---	---
58	-0.999999991354167	0.999995822493938	-0.999999999999985	-0.999999999069124	0.995383757926381	---
59	-0.999999991354167	0.999995822493933	-0.999999999999984	---	---	---
60	-0.999999991354167	0.999995822493939	-0.999999999999985	-0.999999999069124	---	---
61	-0.999999991354167	0.999995822493939	---	---	---	---
62	-0.999999991354167	0.999995822493938	---	---	---	---
63	-0.999999991354167	-1	1	-0.999999999069100	0.995574471619691	-0.0101327917421054
64	-0.999999991354167	0.999995822493935	-0.999999999999984	-0.999999999069124	0.995383758158198	---
65	-0.999999991354167	0.999995822493935	-0.999999999984860	-0.999999999069124	0.995383757926381	---
66	-0.999999991354167	0.999995822493935	-0.999999999999985	---	---	---
67	-0.999999991354167	0.999995822493936	-0.999999999999984	-0.999999999069124	0.995383757926381	---
68	-0.999999991354167	0.999995822493935	-0.999999999999984	---	---	---
69	-0.999999991354167	0.999995822493934	-0.999999999999985	-0.999999999069124	---	---

70	-0.999999991354167	0.999995822493933	-0.999999999999985	---	---	---
71	-0.999999991354167	0.999995822493937	-0.999999999999985	-0.999999999069124	---	---
72	-0.999999991354167	0.999995822493937	---	---	---	---
73	-0.999999991354167	0.999995822493937	---	---	---	---
74	1	0.999995822493937	---	---	---	---
75	-0.999999991354167	0.999995822493937	-0.999999999999985	---	---	---
76	-0.999999991354167	0.999995822493935	---	---	---	---
77	-0.999999991354167	0.999995822493935	-0.999999999971816	-1	-1	---
78	-0.999999991354167	0.999995822493933	-0.999999999999984	-0.999999999069001	0.995901303741688	---
79	-0.999999991354167	0.999995822493932	-0.999999999999985	-0.999999999069124	0.995383757926381	---
80	-0.999999991354167	0.999995822493933	---	---	---	---
81	-0.999999991354167	0.999995822493938	-0.999999999999982	-0.999999999068885	0.996030072506866	-0.0101327917421054
82	-0.999999991354167	0.999995822493938	-0.999999999999985	-0.999999999069124	0.995383757926381	---
83	-0.999999991354167	0.999995822493938	---	---	---	---
84	-0.999999991354167	0.999995822493938	---	---	---	---
85	-0.999999991354167	0.999995822493932	-0.999999999999985	---	---	---
86	-0.999999991354167	0.999995822493928	---	---	---	---
87	-0.999999991354167	0.999995822493934	-0.999999999999985	-0.999999999069120	---	---
88	-0.999999991354167	0.999995822493893	-0.999999999999984	-0.999999999068995	0.995383757926381	-0.0101327917421054
89	-0.999999991354167	0.999995822493937	-0.999999999999984	-0.999999999069124	---	---
90	-0.999999991354167	0.999995822493934	-0.999999999999985	---	---	---
91	-0.999999991354167	0.999995822493933	---	---	---	---
92	-0.999999991354167	0.999995822493928	-0.999999999999979	-0.999999999069128	---	---
93	-0.999999991354167	0.999995822493933	-0.999999999999984	-0.999999999069124	---	---
94	-0.999999991354167	0.999995822493934	-0.999999999999984	---	---	---
95	-0.999999991354167	0.999995822493936	-0.999999999999985	-0.999999999069136	0.994579250495322	1

Table 9. Estimated model parameters *(a_i)* of 95 equations proposed in this work for V_R

DEC	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	a_9	a_{10}
1	5,46724	3,23425	0,14134	-0,00251	81,5262	-231,05565	14569,3707	-641,6868	---	---
2	0,7047	0,1595	-1,71718	1,08259	-1,94149	---	---	---	---	---
3	30,59179	653,4999	0,01046	151,25586	5,23029	---	---	---	---	---
4	0,82145	109,8694	0,58772	---	---	---	---	---	---	---
5	0,62237	-0,81831	-2167,81924	5,6623	-0,15541	5,28312	0,06467	-1,46454	---	---
6	-4,99062	7,18245	0,37645	0,72638	-7,91844	7,9134	1,04618	---	---	---
7	2,35734	0,12819	0,84871	-15,39824	124,1633	1,52844	---	---	---	---
8	0,11176	0,82307	1,90522	0,48868	317,8094	---	---	---	---	---
9	31,13	0,80671	-0,03741	1,49907	-1,54291	5,38275	0,51636	---	---	---
10	-0,00566	-0,11398	13,44069	0,64077	---	---	---	---	---	---
11	-0,00566	-0,11398	13,44069	0,64077	---	---	---	---	---	---
12	0,43138	0,05727	0,43138	0,05727	1,46907	0,06266	0,06577	0,06266	0,0658	
13	5,25617	1,24579	3,39823	-0,14114	-0,46697	0,03503	---	---	---	---
14	0,28548	8,82E-05	-0,41984	-0,13754	---	---	---	---	---	---
15	0,28548	8,82E-05	-0,41984	-0,13754	---	---	---	---	---	---
16	0,28548	8,82E-05	-0,41984	-0,13754	---	---	---	---	---	---
17	0,28548	8,82E-05	-0,41984	-0,13754	---	---	---	---	---	---
18	1,78718	-0,01211	0,82303	-5,72E-04	0,00737	-1,11852	---	---	---	---
19	140,0477	1,11355	139,73204	1,12568	---	---	---	---	---	---

20	1,04526	-8,28701	53,46308	-0,00385	-0,00697	---	---	---	---	---
21	0,839	-3,31382	0,1009	0,7726	-3,40032	---	---	---	---	---
22	140,0477	1,11355	139,73204	1,12568	---	---	---	---	---	---
23	0,839	-3,31382	0,1009	0,7726	-3,40032	---	---	---	---	---
24	42,38533	0,53637	3,7685	0,16069	---	---	---	---	---	---
25	42,38533	0,53637	3,7685	0,16069	---	---	---	---	---	---
26	0,80321	1,05509	-0,69389	1,67272	-0,84698	---	---	---	---	---
27	13,4411	0,64078	0,00566	-0,11389	---	---	---	---	---	---
28	13,09366	2,38657	-0,1929	66,69841	2,26205	5,58112	0,48233	---	---	---
29	2,3488	11,41734	0,76971	15,51808	---	---	---	---	---	---
30	3,4411	0,31051	1,25952	---	---	---	---	---	---	---
31	1538,23853	233,5121	1,02985	0,54834	1,02984	0,54834	---	---	---	---
32	1,326	11,17761	0,69932	3,62678	1,49639	---	---	---	---	---
33	15,27358	12,49652	0,8475	12,94452	0,87458	---	---	---	---	---
34	10,00211	1,20503	12,49918	0,84795	12,92435	0,87369	---	---	---	---
35	0,98275	1416822	-91,3627	---	---	---	---	---	---	---
36	0,02948	0,02948	-7,74282	0,62012	12,14833	---	---	---	---	---
37	-0,00672	0,61951	12,13205	---	---	---	---	---	---	---
38	-22,92583	0,29351	-23,20661	-0,46042	---	---	---	---	---	---
39	5,51294	0,5985	5,71675	0,59854	---	---	---	---	---	---
40	0,13208	1,57271	5,49E-04	0,39421	---	---	---	---	---	---
41	9,43766	0,36225	3,77885	---	---	---	---	---	---	---
42	-1,37005	4,80184	0,07102	-0,21912	---	---	---	---	---	---
43	-3,77778	4,17944	1,09538	0,47941	-1,48989	0,47994	-1,51995	---	---	---
44	15,52642	0,48968	-0,56205	0,21501	26,22675	0,62947	---	---	---	---
45	1,46397	0,41909	1,27281	-0,75241	---	---	---	---	---	---
46	-1,45852	0,61417	1,86424	0,24775	---	---	---	---	---	---
47	0,68061	48,67717	0,67952	0,7341	8,39397	0,49495	---	---	---	---
48	3,82919	3,16677	---	---	---	---	---	---	---	---
49	0,51544	0,05772	0,51543	0,05772	---	---	---	---	---	---
50	1,03087	0,05772	---	---	---	---	---	---	---	---
51	1,18032	1,12768	0,00793	2,17793	1,13892	---	---	---	---	---
52	1,03087	0,05772	---	---	---	---	---	---	---	---
53	3606,82293	-158,336	0,00976	---	---	---	---	---	---	---
54	119,19161	0,99732	---	---	---	---	---	---	---	---
55	1,14272	-1,60886	53,30105	1,12186	6,60203	---	---	---	---	---
56	84,75332	1,02513	---	---	---	---	---	---	---	---
57	1,43E+11	-24,18817	1,60002	0,59854	11,23069	---	---	---	---	---
58	36,61242	0,78343	-31,62791	---	---	---	---	---	---	---
59	3,4198	-9,01931	10,48399	0,78025	---	---	---	---	---	---
60	16,3626	0,86299	---	---	---	---	---	---	---	---
61	16,3626	0,86299	---	---	---	---	---	---	---	---
62	0,49644	1,43959	1,1078	20,84757	3,95477	1,1078	---	---	---	---
63	0,72842	-6,7E+13	1,47E+15	0,75769	0,07743	---	---	---	---	---
64	981,66374	11,342	0,59957	3,3678	3,3678	---	---	---	---	---
65	1,03096	0,05778	1666,21239	---	---	---	---	---	---	---
66	47812,8389	6,58549	-0,69044	0,02952	-64,9304	---	---	---	---	---

67	1,01697	10,97746	0,58764	---	---	---	---	---	---	---
68	1,02959	19,14503	0,58764	0,57709	---	---	---	---	---	---
69	0,83798	35,6977	4,19571	---	---	---	---	---	---	---
70	381985,405	6,32299	-2,76517	7234379,943	---	---	---	---	---	---
71	11,23069	0,59854	---	---	---	---	---	---	---	---
72	11,34467	0,59852	---	---	---	---	---	---	---	---
73	1,16673	0,59895	---	---	---	---	---	---	---	---
74	-2,09E+12	-135,7754	8,77291	---	---	---	---	---	---	---
75	0,13993	0,59865	---	---	---	---	---	---	---	---
76	1186,6152	0,80952	0,00961	0,43432	3,37303	---	---	---	---	---
77	0,47278	0,14951	0,7639	-0,00231	0,60929	---	---	---	---	---
78	0,15626	-30,53205	3,86E+27	3,12853	-30,1431	---	---	---	---	---
79	112,49272	111,04957	---	---	---	---	---	---	---	---
80	5,01813	-0,1044	14,99176	1,30972	-1,54501	1,92013	---	---	---	---
81	1,51376	13,07375	0,57427	20,60312	3,09849	---	---	---	---	---
82	1,17E-32	-0,05505	---	---	---	---	---	---	---	---
83	380,45305	1,3526	---	---	---	---	---	---	---	---
84	34,63708	1,35259	0,09104	---	---	---	---	---	---	---
85	-41,33985	45,87023	---	---	---	---	---	---	---	---
86	5,89E+08	-3,83413	26,2177	-0,08372	---	---	---	---	---	---
87	1,65567	0,34001	142,80576	2,5704	-0,02235	0,19099	---	---	---	---
88	13,19441	6,67883	0,56887	19,61145	---	---	---	---	---	---
89	-11943,269	49,03662	49,03637	---	---	---	---	---	---	---
90	1,59223	75,13448	---	---	---	---	---	---	---	---
91	0,49625	28,17097	3,98293	6,53106	---	---	---	---	---	---
92	5,89E+08	-3,83413	26,2177	-0,08372	---	---	---	---	---	---
93	12,13205	0,61951	0,00672	---	---	---	---	---	---	---
94	0,02173	-0,51337	0,20336	-0,16334	0,59758	14,759	---	---	---	---
95	0,99713	0,24519	1,37408	-0,56078	25,37448	0,48862	---	---	---	---

Table 10. Normalized correlation constants *(a_n)* ofV_R

DEC	a_1	a_2	a_3	a_4	a_5	a_6
1	0.871921182270907	0.999999957706903	-1	-0.999995743741039	-0.234693648269660	-1
2	0.871921182266641	0.999999957706812	-1	-0.999995443757433	-0.670852573994134	---
3	0.871921182293410	0.999999957726314	-1	-0.999953927289804	-0.633376565489139	---
4	0.871921182266746	0.999999957710086	-1	---	---	---
5	0.871921182266567	0.999999957706782	-1	-0.999994177664060	-0.661519444802971	0.922902235485151
6	0.871921182261540	0.999999957707021	-1	-0.999995542234219	-0.702085019639975	0.944302750059852
7	0.871921182268121	0.999999957706811	-1	-1	-0.0118942425114921	0.892353364618423
8	0.871921182266110	0.999999957706831	-1	-0.999995607948073	1	---
9	0.871921182293892	0.999999957706831	-1	-0.999995328618578	-0.668769801311492	0.923712846244111
10	0.871921182266005	0.999999957706803	-1	-0.999995565901712	---	---
11	0.871921182266005	0.999999957706803	-1	-0.999995565901712	---	---
12	0.871921182266396	0.999999957706809	-1	-0.999995727214433	-0.653030753530205	0.880427468419803
13	0.871921182270718	0.999999957706844	-1	-0.999995782066287	-0.663147496027327	0.880202664894057
14	0.871921182266266	0.999999957706807	-1	-0.999995781071042	---	---
15	0.871921182266266	0.999999957706807	-1	-0.999995781071042	---	---
16	0.871921182266266	0.999999957706807	-1	-0.999995781071042	---	---

17	0.871921182266266	0.999999957706807	-1	-0.999995781071042	---	---
18	0.871921182267611	0.999999957706806	-1	-0.999995743205265	-0.660668840815614	0.870817138034694
19	0.871921182391444	0.999999957706840	-1	-0.999995431844896	---	---
20	0.871921182266946	0.999999957706560	-1	-0.999995744111491	-0.660743774229908	---
21	0.871921182266761	0.999999957706708	-1	-0.999995529456371	-0.678475664145720	---
22	0.871921182391444	0.999999957706840	-1	-0.999995431844896	---	---
23	0.871921182266761	0.999999957706708	-1	-0.999995529456371	-0.678475664145720	---
24	0.871921182303973	0.999999957706823	-1	-0.999995698623239	---	---
25	0.871921182303973	0.999999957706823	-1	-0.999995698623239	---	---
26	0.871921182266729	0.999999957706838	-1	-0.999995280611801	-0.665133231506104	---
27	0.871921182278049	0.999999957706826	-1	-0.999995774532831	---	---
28	0.871921182277737	0.999999957706878	-1	-0.999977303797725	-0.648887050680384	0.925326826533732
29	0.871921182268114	0.999999957707148	-1	-0.999991452963643	---	---
30	0.871921182269092	0.999999957706816	-1	---	---	---
31	0.871921183643743	0.999999957713778	-1	-0.999995591454642	-0.655325942062989	0.884379063656295
32	0.871921182267198	0.999999957707141	-1	-0.999994740398028	-0.652887993357367	---
33	0.871921182279690	0.999999957707180	-1	-0.999992164442593	-0.656137250424440	---
34	0.871921182274968	0.999999957706843	-1	-0.999995508625328	-0.593171392157283	0.887026180091382
35	0.871921182266890	1	-1	---	---	---
36	0.871921182266036	0.999999957706808	-1	-0.999995571610551	-0.597226470829530	---
37	0.871921182266004	0.999999957706825	-1	---	---	---
38	0.871921182245476	0.999999957706816	-1	-0.999995870333512	---	---
39	0.871921182270948	0.999999957706825	-1	-0.999995577576495	---	---
40	0.871921182266128	0.999999957706854	-1,00E+00	-0.999995634064976	---	---
41	0.871921182274463	0.999999957706818	-1	---	---	---
42	0.871921182264783	0.999999957706950	-1	-0.999995803624413	---	---
43	0.871921182262626	0.999999957706932	-1	-0.999995610510830	-0.668492746246928	0.883822546784742
44	0.871921182279916	0.999999957706822	-1	-0.999995683606089	-0.523659938161644	0.885039154501166
45	0.871921182267321	0.999999957706820	-1	-0.999995951056223	---	---
46	0.871921182264704	0.999999957706825	-1	-0.999995674554884	---	---
47	0.871921182266620	0.999999957708260	-1	-0.999995540099970	-0.616844812062921	0.883944671320444
48	0.871921182269440	0.999999957706901	---	---	---	---
49	0.871921182266471	0.999999957706809	-1	-0.999995727090027	---	---
50	0.871921182266933	0.999999957706809	---	---	---	---
51	0.871921182267067	0.999999957706840	-1	-0.999995140942907	-0.654755946468070	---
52	0.871921182266933	0.999999957706809	---	---	---	---
53	0.871921185496483	0.999999957702080	-1	---	---	---
54	0.871921182372765	0.999999957706837	---	---	---	---
55	0.871921182267033	0.999999957706759	-1	-0.999995432900963	-0.626208562579591	---
56	0.871921182341920	0.999999957706838	---	---	---	---
57	1,00E+00	0.999999957706085	-1	-0.999995577576495	-0.602021582286452	---
58	0.871921182298802	0.999999957706830	-1	---	---	---
59	0.871921182269073	0.999999957706538	-1	-0.999995527341475	---	---
60	0.871921182280665	0.999999957706833	---	---	---	---
61	0.871921182280665	0.999999957706833	---	---	---	---
62	0.871921182266454	0.999999957706850	-1	-0.999989979588261	-0.640041772504453	0.888930948582601
63	0.871921182266662	-1,00E+00	-0.999999999999238	-0.999995533578347	-0.660302743534903	---

64	0.871921183145243	0.999999957707145	-1	-0.999994811994890	-0.643108973772782	---
65	0.871921182266933	0.999999957706809	-1	---	---	---
66	0.871921225089869	0.999999957707004	-1	-0.999995734886118	-1	---
67	0.871921182266921	0.999999957707135	-1	---	---	---
68	0.871921182266932	0.999999957707378	-1	-0.999995583506500	---	---
69	0.871921182266760	0.999999957707872	-1	---	---	---
70	0.871921524393556	0.999999957706996	-1	1	---	---
71	0.871921182276069	0.999999957706825	---	---	---	---
72	0.871921182276171	0.999999957706825	---	---	---	---
73	0.871921182267055	0.999999957706825	---	---	---	---
74	-1,00E+00	0.999999957702754	-1	---	---	---
75	0.871921182266135	0.999999957706825	---	---	---	---
76	0.871921183328809	0.999999957706831	-1	-0.999995622976281	-0.643081644501042	---
77	0.871921182266433	0.999999957706811	-1	-0.999995743685747	-0.657523518588869	---
78	0.871921182266150	0.999999957705896	1,00E+00	-0.999994878142782	-0.818219584166580	---
79	0.871921182366765	0.999999957710122	---	---	---	---
80	0.871921182270504	0.999999957706804	-1	-0.999995380965731	-0.668780774824045	0.895540237329223
81	0.871921182267366	0.999999957707197	-1	-0.999990047168201	-0.644516248375528	---
82	0.871921182266010	0.999999957706805	---	---	---	---
83	0.871921182606765	0.999999957706847	---	---	---	---
84	0.871921182297033	0.999999957706847	-1	---	---	---
85	0.871921182228984	0.999999957708176	---	---	---	---
86	0.872448723690103	0.999999957706692	-1	-0.999995766192120	---	---
87	0.871921182267493	0.999999957706817	-1	-0.999995032441786	-0.660824142145656	0.881471588450892
88	0.871921182277827	0.999999957707006	-1	-0.999990321322419	---	---
89	0.871921171568949	0.999999957708271	-1	---	---	---
90	0.871921182267436	0.999999957709050	---	---	---	---
91	0.871921182266454	0.999999957707648	-1	-0.999993937489185	---	---
92	0.872448723690103	0.999999957706692	-1	-0.999995766192120	---	---
93	0.871921182276876	0.999999957706825	-1	---	---	---
94	0.871921182266029	0.999999957706792	-1	-0.999995788203635	-0.657584708985060	1
95	0.871921182266903	0.999999957706814	-1	-0.999995898078747	-0.528113459849224	0.883893169101191

The best performing model was selected based on the smallest reduced chi-Sqr, residual sum of residual (≈0) and the DEC were classed according to adjusted R-squared. such us, the minimum value of adjusted R-squared that was taken greater than or equal 0.97. The parameters of optimizing models are presented in the Tables 5–10.

3.2. Graphical performance of the regression results

3.2.1. Fitted curves plot

The Figure 2 indicates the validation of the best-fit correlation (DEC 1) to follow the scatterplot of each data points:alimentation, permeate and rejection witch it presented by graphics A,B and C respectively. So, the fit DEC 1 is closely related by thethe area of 95% confidence bands and followed the 95% prediction bands. Also, DEC 1 predicted adequately scatterplot of each data points A, B and C. thus, this includes both the uncertainty in the true position of DEC 1 (enclosed by the confidence bands), and also accounts for scatter of data around the three graphs (A, B and C).

3.2.2. Residual plots

Figure 3 below present residuals plot versus fits values using DEC 1.These residual plots can be used to assess the quality of the correlation regression. Such us,

$$\text{The Residual Value} = \text{Observed Value of V} - \text{Predicted Value of V} \quad (5)$$

where: V: cumulative dimensionless volume of the filtrate at time τ.

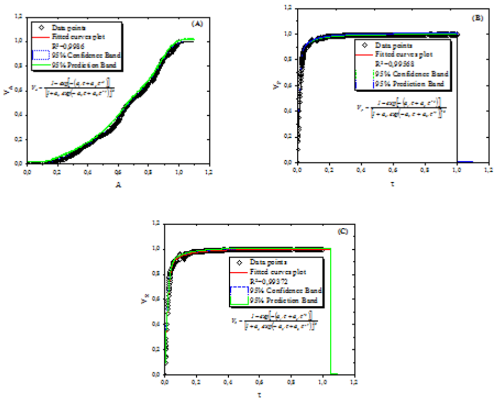


Figure 3. Fitted curves plot of DEC 1 of the filtrate at time τ versus data points for the alimentation (A), permeate(B) and rejection (C).

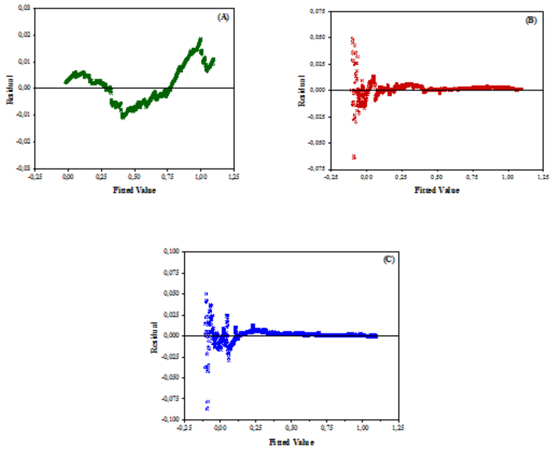


Figure 4. Residuals values vs. Fits Plot using DEC 1for the alimentation (A), permeate(B) and rejection (C).

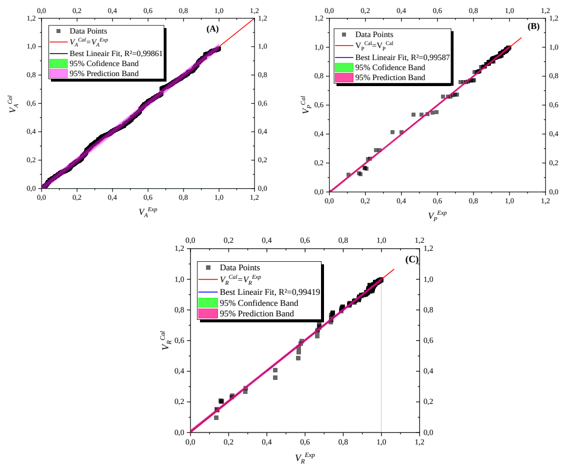


Figure 5. Scatter plot of the predicted values of alimentation (A), permeate(B) and rejection (C) versus experimental values by DEC 1 correlation for the validation set.

The underlying statistical assumptions were considered about residuals to Adj. R-Square. For these assumptions to hold true for a particular regression model, the residuals would have to be randomly distributed around zero (Figure 4). The scatter plot (A, B and C) of the residuals disordered the excellent regression. How over, the maximum residual values for the three graphics A, B and C move away to the zero line by 0,075 in absolute value.This result was argument by the regression equation, line of DEC 1 i.e., predicted vs experimental validation results which it indicates excellent significant of DEC 1 for the prediction of cumulative dimensionless volume (Figure 5).

4. Conclusion

The novel dimensionless empirical correlation proposed in this study the kinetic separation performance of three cumulative dimensionless volume: alimentation, permeate and rejection as a function of the dimensionless filtration time and vice versa. Results show that 95 correlations as a whole correlates with the experimental data with a least R^2 was around 0.96796 and COD of 0.96797 in comparison to the best correlation with R^2 of 0.99796 and COD of 0.99796 for neglegeable errors and perfect alignment of correlation to RO kinetic separation according to statistical criteria.

Acknowledgments

Dr. Ahmed AZIZI thanks the water treatment services of the Antibiotic industry, SAIDAL in Medea (Algeria), for their assistance.

References

Aladwani S.H., Al-Obaidi M.A., and Mujtaba I.M. (2021), Performance of reverse osmosis based desalination process using spiral wound membrane: Sensitivity study of operating parameters under variable seawater conditions. *Cleaner Engineering and Technology*, **5**, 100284. https://doi.org/10.1016/j.clet.2021.100284.

Alkarkhi A.F.M., and Alqaraghuli W.A.A. (2020), Chapter 7 - Regression Analysis, *Applied Statistics for Environmental Science with R*, 113–132. https://doi.org/10.1016/B978-0-12-818622-0.00007-1.

Al-Obaidia M.A., Alsarayreh A.A., Al-Hroub A.M., Alsadaied S., and Mujtaba I.M. (2018). Performance analysis of a medium-sized industrial reverse osmosis brackish water desalination plant. *Desalination,* **443**, 272–284. semihttps://doi.org/10.1016/j.desal.2018.06.010.

Bartman R. (2011). Control and monitoring of reverse osmosis water desalination, PhD Thesis, University of California, Los Angeles.

Choi J.S., and Kim J.T. (2015). Modeling of full-scale reverse osmosis desalination system: Influence of operational parameters, *Journal of Industrial and Engineering Chemistry*, **21(1)**, 261–268. doi: 10.1016/j.jiec.2014.02.033.

Chong Y.K., Liang Y.Y., Lau W.J., and Weihs G.A.F. (2022). Chapter 15 - Modelling flow and mass transfer inside spacer-filled channels for reverse osmosis membrane modules, 60 Years of the Loeb-Sourirajan membrane principles. *New Materials, Modelling, Characterization, and Applications*, 413–432. https://doi.org/10.1016/B978-0-323-89977-2.00015-4.

Dimitriou E., Boutikos P., Mohamed E.S., Koziel S., and Papadakis G. (2017). Theoretical performance prediction of a reverse osmosis desalination membrane element under variable operating conditions. *Desalination*, **419**, 70–78. http://dx.doi.org/10.1016/j.desal.2017.06.001.

Elimelech M., and Phillip W.A. (2011). The future of seawater desalination: energy, technology, and the environment. *Science*, **333(6034)**, 712–717. doi: 10.1126/science.1200488.

Ghernaout D. (2017). Reverse osmosis process membranes modeling – a historical overview. *Journal of Civil, Construction and Environmental Engineering*, **2(4)**, 112–122. doi: 10.11648/j.jccee.20170204.12.

Gu B., Adjiman C.S., and Xu X.Y. (2021). Correlations for concentration polarization and pressure drop in spacer-filled RO membrane modules based on CFD simulations. *Membranes*, **11(5)**, 338. https://doi.org/10.3390/membranes11050338.

Haluch V., Zanoelo E.F., and Hermes C.J.L. (2017). Experimental evaluation and semi-empirical modeling of a small-capacity reverse osmosis desalination unit, *Chemical Engineering Research and Design,* **122**, 243–253. http://dx.doi.org/10.1016/j.cherd.2017.04.006.

Hoek E.M.V., Allred J., Knoell T., and Jeong B.H (2008). Modeling the effects of fouling on full-scale reverse osmosis processes. *Journal of Membrane Science*, **314**(1–2), 33–49. doi: 10.1016/j.memsci.2008.01.025.

Ibrar I., Yadav S., Altaee A., Hawari A., Nguyen V., and Zhou J. (2020). A novel empirical method for predicting concentration polarization in forward osmosis for single and multicomponent draw solutions. *Desalination*, **494**, 114668. doi: 10.1016/j.desal.2020.114668.

Jogdand A., and Chaudhuri A. (2015). Modeling of concentration polarization and permeate flux variation in a roto-dynamic reverse osmosis filtration system. *Desalination*, **375**, 54–70. doi: 10.1016/j.desal.2015.07.011.

Ling B., Xie P., Ladner D., and Battiato I. (2021). Dynamic modeling of fouling in reverse osmosis membranes. *Membranes*, **11(5)**, 349. https://doi.org/10.3390/membranes 11050349.

Mehdizadeh H. (1990). Modeling of transport phenomena in reverse osmosis membranes, PhD Thesis, McMaster University, Ontario.

Mostoufi N., and Constantinides A. (2023), Chapter 8 - Linear and nonlinear regression analysis, *Applied Numerical Methods for Chemical Engineers*, 403–476. doi: 10.1016/b978-0-12-822961-3.00008-x.

Najid N., Hakizimana J.N., Kouzbour S., Gourich B., Ruiz-García A., Vial C., Stiriba Y., and Semiat R (2022). Fouling control and modeling in reverse osmosis for seawater desalination: A review, *Computers & Chemical Engineering*, **162**(206), 107794. doi:10.1016/j.compchemeng.2022.107794.

Niewersch C., Rieth C., Hailemariam L., Oriol G.G., and Warczok J. (2020). Reverse osmosis membrane element integrity evaluation using imperfection model. *Desalination*, **476**, 114175. https://doi.org/10.1016/j.desal.2019.114175.

Pearson J.L., Michael P.R., Ghaffour N., and Missimer T.M. (2021). Economics and energy consumption of brackish water reverse osmosis desalination: innovations and impacts of feed water quality. *Membranes*, **11(8)**, 616. https://doi.org/10.3390/membranes 11080616.

Qasim M., Badrelzaman M., Darwish N.N., Darwish N.A., and Hilal N. (2019), Reverse osmosis desalination: A state-of-the-art review, *Desalination*, **459**, 59–104. doi:10.1016/J.DESAL.2019.02.008.

Reverberi A.P., Meshalkin V.P., Cerrato C., and Savina Yu O. (2011). Dynamics of a reverse osmosis unit with application to pulsating regimes for process optimization. *Theoretical Foundations of Chemical Engineering*, **45(2)**, 190–197. doi: 10.1134/S0040579511020114.

Siegel A.F., and Wagner M.R. (2022). Chapter 11 - Correlation and regression: measuring and predicting relationships. *Practical Business Statistics (Eighth Edition)*, 313–370. https://doi.org/10.1016/B978-0-12-820025-4.00011-7.

Soltanieh M., and Gill W.N. (1981). Review of reverse osmosis membranes and transport models. *Chemical Engineering Communications*, **12**(4–6), 279–363. https://doi.org/10.1080/00986448108910843.

Tyagi K., Rane C., Harshvardhan, and Manryd M. (2022). Chapter 4- Regression analysis. *Artificial Intelligence and Machine Learning for EDGE Computing*, 53–63. https://doi.org/10.1016/B978-0-12-824054-0.00007-1.

Wilcox R.R. (2022). Chapter 11 - More regression methods. *Introduction to Robust Estimation and Hypothesis Testing (Fifth edition)*, 653–772. https://doi.org/10.1016/B978-0-12-820098-8.00017-8.

Williams L.L., and Quave K. (2019). Chapter 9 - Regression analysis. *Quantitative Anthropology, A Workbook*, 115–122. Doi :10.1016/B978-0-12-812775-9.00009-8.

Xu J., Tran T.N., Lin H., and Dai N. (2020). Modeling the transport of neutral disinfection byproducts in forward osmosis: Roles of reverse salt flux. *Water Research*, **185**, 116255. doi: 10.1016/j.watres.2020.116255.

Zhang X., Jiang J., Yuan F., Song W., Li J., Xing D., Zhao L., Dong W., Pan X., and Gao X. (2022). Estimation of water footprint in seawater desalination with reverse osmosis process. *Environmental Research*, **204**(Part D), 112374. doi: 10.1016/j.envres.2021.112374.