Summary of PhD thesis

EXAMINATION OF STRUCTURAL MATERIALS' PROPERTY CHANGES BY VIBRATION DIAGNOSTIC METHODS

Dénes László Kocsis

Supervisor: Dr. Róbert Horváth

University of Debrecen

Doctoral School of Chemistry

Debrecen, 2015.

I. INTRODUCTION AND AIMS

The vibration diagnostic techniques are increasingly used to solve a wide range of technical problems. Their application is quite diverse and continues to expand throughout industry.

The actuality of the theme was brought to the attention of our research team by incidents from industry. Pipelines - made of various materials - used for transporting geothermal energy often encounter clogging and fractures.

The aim of the research team was to examine the property changes of materials by vibration diagnostic techniques. Various types of plastics and materials containing metal and human bone were examined in our research. In this thesis, mainly the results of PVC specimens are presented. The tests were carried out on fiber specimens made of PVC with different diameters, and stainless steel and PVC pipes.

An important part of the study was the investigation of the property changes related to aging. For plastic products the examination of physical and chemical aging is particularly important, because sometimes unexpected degradation events happen long before the end of the planned lifecycle. Accordingly, material property changes were evaluated after different artificial aging time.

In the first test series, long-term tensile and relaxation tests of PVC fibers were included. The aim was to investigate and describe the behavior of the examined material with sufficient precision using the applied load at constant temperature, and to gain information about the aging process using this model. Therefore, this work tries to minimize the number of necessary material parameters, which are used to characterize the possible changes and the level of degradation due to UV-radiation.

During the second series of experiments, fibers of the same PVC material were examined as vibrating strings. In this case, UV light was applied again for the aging of the fibers. The tests were done on a self-constructed vibrating table, where the fibers were stretched one by one for each measurement as strings by a tensional force. After the diverted and stretched fibers were twanged the motion of the string was recorded and vibration parameters were also measured. Our aim was to investigate the level of degradation from the parameters of the oscillating motion.

Reduction in inner diameter of pipes, as a characteristic failure (for example limescale deposition) was modeled in the third test series. To this end, the different phases of deposition are artificially simulated in the model experiments. Characterization of the degradation of the pipes was performed by vibration based measurements.

II. EXPERIMENTAL METHODS

For the three series of experiments specific equipment and experimental systems were applied. The aim of the first experiment was to determine material parameters from long-term creep and relaxation tests. Soft PVC fibers were used in the measurements, which were extruded from LE 411 type granulate[1] produced by BorsodChem (Kazincbarcika, Hungary). During the experiment the fibers were pulled out over a table with one end fixed to the load cell. The other end was run over a pulley and it was loaded with an attached weight (50 N) when the tests were initiated. Both unaged and artificially aged by UV light specimens were examined. In each case during this experiment, the weighted end was stopped by placing blocks under it after three and a half hours creep period. The longitudinal and transverse values were determined during the tests.

The examinations were based on the deviatoric and spherical split. After the splitting we were looking for the proper material model and the corresponding parameter values. It was an important goal to explore which model can be used for describing the material behavior accurately. Another aim was to identify the parameter changes due to artificial aging, and to obtain information about their changing direction and magnitude.

In the second series of experiments, thinner PVC specimens were used. The diameters of the fibers were approximately 2 mm. The tests were done on a self-constructed vibrating table, where the fibers were stretched one by one for each measurement as strings by a tensional force. After the diverted and stretched fibers were twanged, the motion of the string was recorded and vibration parameters were measured. Based on the visual and video monitoring, the vertical vibration of the fibers was neglected due to the tensioning. The oscillation was recorded by a camera.

[1]Material composition: S-5070 PVC (K=70) 60.30 wt. %; Bis(2-ethylhexyl) phthalate 37.39 wt. %; TM181-FSM stabilizer 0.90 wt. %; MMA/EA 1.21 wt.%; E-wax 0.18 wt.%; Uvitex OB fluorescent whitener 0.02 wt.%.

Moving frame by frame, the deflections were measured by the help of the scale under the string. We also affixed a triaxial vibration accelerometer on the table surface. The damped oscillation was analyzed in this work. The material parameters from the equation of the vibration were determined and their changing due to aging was evaluated.

Reduction in inner diameter of pipes, as a characteristic failure (for example limescale deposition) was modeled in the third test series. To this end, the different phases of deposition are artificially simulated in the model experiments. During the experiments screed concrete was applied in different thickness to the inner wall of the pipes. Both stainless steel (pipe type used by Aquaplus Ltd., Heat N 0416950 EN 1.4541 TP 321 EN 10217-7 TC1 W1 CR, 88,9*2,0 mm, production date: 14.07.2009) and PVC pipes (produced by Pipelife Hungária Ltd., KM PVC-U pressure pipe, SDR 33 PN6, 90*2,8 mm, extruded pipe) were examined. In both cases inside diameter decrease occurred due to deposition.

During the model experiments, the same vibration tests were performed to evaluate the status of the pipe section. The measurements were executed on a metalworking lathe, where the pipe was supported by two steady rests. For the vibration test, two triaxial accelerometers were glued to the pipe. Tests were performed with impulse excitation of vibration from various directions and at multiple locations. Property changes were evaluated based on the results and the experimental system was also analyzed by the finite element method (FEM).

By the series of experiments presented in the dissertation property changes of structural elements after different aging times were examined by material property and vibration tests.

III. NOVEL SCIENTIFIC ACHIEVEMENTS

1. Modelling the long-term creep and relaxation of the examined soft PVC (LE-411/009) and determining the values of the applied model's material parameters.

1.1 **We found, that during the creep of the examined soft PVC (LE-411/009) the Poynting-Thomson model described the phenomenon with sufficient accuracy.** In this case, it was found that besides the stress and deformation the use of their first derivative gives an accurate (Table I) description. The model's material parameter values were determined.

Table I The average absolute deviation (AAD) between measured and modeled data pairs and R^2 values

(measured ε^d values min: 0.1054 max: 0.2071; modeled ε^d values min: 0.1083 max: 0.2042)

Aging time [h]	Specimen (index)	AAD	R^2
0	unaged1 (01)	0.0016	0.9876
	unaged2 (02)	0.0023	0.9727
	unaged3 (03)	0.0018	0.9811
2541	1aged1 (a1)	0.0022	0.9717
	1aged2 (a2)	0.0022	0.9743
	1aged3 (a3)	0.0025	0.9668
4000	2aged1 (2a1)	0.0023	0.9701
	2aged2 (2a2)	0.0022	0.9817
	2aged3 (2a3)	0.0021	0.9628

1.2 We found, that for the relaxation of the examined soft PVC (LE-411/009) a modified Burgers model should be used. Here, we suggest a model which includes the stress and deformation and also their first and second order time derivatives. We call this model modified Burgers model. For the introduced model material parameter values were calculated, which describe the material behavior very accurately (Table II).

Table II The average absolute deviation (AAD) between measured and modeled data pairs and R^2 values

(measured σ^d values min: 616.86 kPa max: 865.76 kPa; modeled σ^d values min: 617.82 kPa max: 868.37 kPa)

Aging time [h]	Specimen (index)	AAD	R^2
0	unaged1 (01)	3.4267	0.9923
	unaged2 (02)	3.9931	0.9876
	unaged3 (03)	2.9725	0.9943
2541	1aged1 (a1)	5.2481	0.9720
	1aged2 (a2)	3.3692	0.9890
	1aged3 (a3)	5.2015	0.9819
4000	2aged1 (2a1)	4.4415	0.9768
	2aged2 (2a2)	4.3838	0.9769
	2aged3 (2a3)	3.8517	0.9850

2. For the aging characterization of the examined soft PVC (LE-411/009) in addition to the former relaxation parameters (τ: relaxation time, G: shear modulus), we recommend using the inertia factor (ξ^d) also, which describes the dynamic behavior more accurately. The determined parameter values well characterize (Fig. 1) the material's behavior. The determination of parameters were always performed for the same interval, but the obtained parameter values well characterize the overall relaxation. The obtained parameters clearly indicate the aging of the material (Table III).

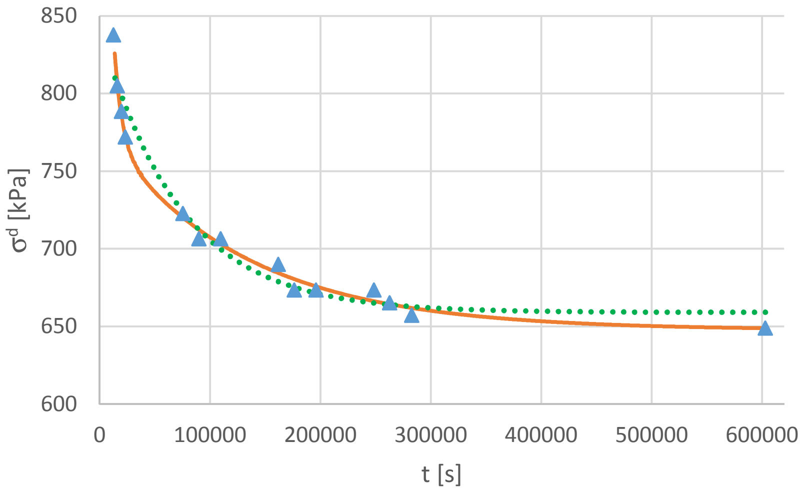

Fig. 1 An example for the illustration of using the inertia factor (specimen index: 2a2)

continuous curve: contains ξ^d (average absolute deviation of measured and modeled data pairs: 4.38 kPa)

dashed curve: without ξ^d (average absolute deviation of measured and modeled data pairs: 7.12 kPa)

Table III The average results and standard deviation (SD) for the relaxation

Aging time [h]	**τ [h]**		**ξ^d [h²]**		**G [MPa]**	
	value	*SD*	**value**	*SD*	**value**	*SD*
0	**143.87**	*64.77*	**592.20**	*229.67*	**1.41**	*0.11*
2541	**100.75**	*25.77*	**567.31**	*262.60*	**1.58**	*0.04*
4000	**35.49**	*2.78*	**58.85**	*18.97*	**2.04**	*0.18*

3. We found, that adding f_t angular acceleration to the general equation of vibrating string in the case of the stretched soft PVC (LE-411/009) fibers, gives a more accurate description of the damped oscillation. Furthermore, besides the β damping coefficient the f_t angular acceleration also well characterize the aging level. The only new element in the extended equation, which tracks the dynamic changes better, is the f_t.

$$y(t) = A_0 * e^{-\beta t} * cos(2\pi(f_0 + f_t t)t)$$

Where A_0 is the amplitude, β is the damping coefficient, f_0 is the oscillation frequency, f_t is the angular acceleration and φ is the phase.

Table IV The average parameter and standard deviation (SD) values versus aging time

Aging time [h]	**Parameters**					
	β		**f_0 [Hz]**		**f_t [1/s²]**	
	value	*SD*	**value**	*SD*	**value**	*SD*
0	**5.94**	*0.51*	**20.92**	*1.27*	**19.73**	*4.83*
200	**5.97**	*0.17*	**20.45**	*0.83*	**23.88**	*1.35*
1000	**6.81**	*0.39*	**17.95**	*0.05*	**31.78**	*3.20*
2200	**9.52**	*0.09*	**20.54**	*1.46*	**30.91**	*4.07*

4. We found, that the peak values of vibration parameters (acceleration: a_{peak}, velocity: v_{peak}, displacement: d_{peak}) and the decrease of the first natural frequency modes indicate significantly the inner diameter reduction in pipes. Therefore, deposition on the pipe's inner walls can be indicated in a non-destructive way by using vibration accelerometers and external excitation.

IV. POSSIBLE APPLICATIONS OF THE RESULTS

The results presented in the dissertation give the opportunity to understand the examined PVC's material properties better. In the literature, the expansion and clarification of conventional models is a typical research direction. Based on the suggested model, the material behavior can be tracked more accurately. It may result in the exact determination of the thermoplastic materials' response to various loads.

With the aging experiments, accelerated prediction of the material's degradation is possible. The determined material and vibration parameters may serve the prediction of property changes and failures in the case of the examined material.

Modeling the property changes of pipes can be easily transposed to industrial practice. Many examples show the necessity for testing in geothermal systems, where recurring limescale deposition results in pipe failures. In many cases, rupture and cross-sectional narrowing of pipes can cause serious property damage. Using the introduced vibration based techniques, evaluating and tracking the pipe's condition may be possible. The results of the performed model experiment are not only useful for indoor pipes, but it can also well characterize the behavior of underground pipes (trenchless pipe laying, lack of soil compaction over the buried pipe, etc.). Considering the relatively low cost of the measurements, it can be a potentially useful diagnostic method for the evaluation of the pipes' condition.

UNIVERSITY OF DEBRECEN
UNIVERSITY AND NATIONAL LIBRARY

Registry number: DEENK/190/2015.PL
Subject: Ph.D. List of Publications

Candidate: Dénes Kocsis
Neptun ID: MNN73O
Doctoral School: Doctoral School of Chemistry
MTMT ID: 10036962

List of publications related to the dissertation

Hungarian book(s) (1)

1. Bodnár I., Braun M., Horváth R., Tóth L., Trampus P., Varga F., **Kocsis D.**: Geotermikus rendszerek fenntarthatóságának integrált modellezése:1. munkacsoport : geotermikus rendszerek károsodása, befolyásoló tényezők, ellenőrzés és karbantartás. Debreceni Egyetem, Debrecen, 111 p., 2011. ISBN: 9789634734468

Hungarian book chapter(s) (2)

2. Asszonyi C., Szarka Z., Csatár A., Horváth R., **Kocsis D.**, Ván P.: Tömör anyagok képlékeny deformációról.
In: A képlékenység termodinamikájáról. Írták: Asszonyi Csaba, Csatár Attila, Dolezalová Márta, Fülöp Tamás, Horváth Róbert, Kocsis Dénes, Kovács László, Matolcsi Tamás, Szarka Zoltán, Ván Péter, Vásárhelyi Balázs, Hungarian Printing House, Budapest, 9-22, 2012. ISBN: 9789630830720

3. Asszonyi C., Szarka Z., Csatár A., Horváth R., **Kocsis D.**: Anyagok mechanikai tulajdonságainak meghatározása egytengelyű laboratóriumi kísérletekkel.
In: A képlékenység termodinamikájáról. Írták: Asszonyi Csaba, Csatár Attila, Dolezalová Márta, Fülöp Tamás, Horváth Róbert, Kocsis Dénes, Kovács László, Matolcsi Tamás, Szarka Zoltán, Ván Péter, Vásárhelyi Balázs, Hungarian Printing House, Budapest, 125-136, 2012. ISBN: 9789630830720

Address: 1 Egyetem tér, Debrecen 4032, Hungary Postal address: Pf. 39. Debrecen 4010, Hungary
Tel.: +36 52 410 443 Fax: +36 52 512 900/63847 E-mail: publikaciok@lib.unideb.hu, ¤ Web: www.lib.unideb.hu

Foreign language Hungarian book chapter(s) (1)

4. **Kocsis, D.**, Horváth, R., Manó, S., Godó, Z.A.: Vibration analysis of artifically aged pipes.
In: XVII. Épületgépészeti, Gépészeti és Építőipari Szakmai Napok : szakkiállítás és Nemzetközi Tudományos Konferencia 2011. október 13-14. [elektronikus dokumentum]. Szerk.: Kalmár Ferenc, Balla Tibor ; közread. a Debreceni Egyetem Műszaki Kar, Debreceni Egyetem Műszaki Kar, Debrecen, 1-6, 2011. ISBN: 9789634734642

Foreign language scientific article(s) in Hungarian journal(s) (1)

5. **Kocsis, D.**, Horváth, R., Manó, S., Godó, Z.A.: Long-term artifically aging process and vibration analysis of pipes.
Int. Rev. Appl. Sci. Eng. 3 (1), 15-19, 2012. ISSN: 2062-0810.
DOI: http://dx.doi.org/10.1556/IRASE.3.2012.1.2

Foreign language scientific article(s) in international journal(s) (3)

6. **Kocsis, D.**, Deák, G., Kéki, S., Dezső, G., Horváth, R.: Artificial Aging Examination of PVC Fibers as Vibrating String.
EEMJ. "Accepted by publisher" (2015) ISSN: 1582-9596.
IF:1.065 (2014)

7. **Kocsis, D.**: Modeling and vibration analysis of limescale deposition in geothermal pipes.
EEMJ. 13 (11), 2817-2824, 2014. ISSN: 1582-9596.
IF:1.065

8. **Kocsis, D.**, Horváth, R.: Experience acquired in tensile tests of plastics.
Sci. Bul. Ser. C. Fasc. Mech. Trib. Mach. Manuf. Tech. 27, 111-114, 2013. ISSN: 1224-3264.

Hungarian conference proceeding(s) (1)

9. **Kocsis D.**, Horváth R.: Műanyagok öregedésvizsgálata.
In: Proceedings of 18th Building Services, Mechanical and Building Industry days, International Conference [elektronikus dokumentum] : [11-12 October 2012, Debrecen, Hungary]. Ed.: Ferenc Kalmár et al., Debreceni Egyetem, Debrecen, 1-8. [Paper Code: ENV-12-01], 2012. ISBN: 9789634735915

10. Dezső G., **Kocsis D.**, Horváth R.: Kemény polietilén csövek gerjesztett rezgéseinek Szimulációja =Simulation of excited vibrations of high density polyethylene pipes.
    In: Műszaki Tudomány az Észak-kelet Magyarországi Régióban 2012 : konferencia előadásai : Szolnok, 2012. május 10. Szerk.: Pokorádi László, Debreceni Akadémiai Bizottság Műszaki Szakbizottsága, Debrecen, 443-448, 2012. ISBN: 9789637064289

11. Horváth R., Manó S., **Kocsis D.**, Godó Z.A.: Combcsont osteoporosis kimutatása rezgésdiagnosztika segítségével.
    In: IV. Magyar Biomechanikai Konferencia. [S.n.], Pécs, 62, 2010.

Foreign language conference proceeding(s) (2)

12. **Kocsis, D.**, Horváth, R., Manó, S., Godó, Z.A.: Vibration analysis of rheological properties of artificially aged pvc filaments.
    In: International Multidisciplinary Conference, 9-th Edition, Baia Mare - Nyíregyháza, 19-21 May 2011. Bessenyei Publishing House, Nyíregyháza, 127-132, 2011. ISBN: 9786155097188

13. Horváth, R., Godó, Z.A., **Kocsis, D.**, Manó, S.: Analysis of thermal water pipes using the vibration method.
    In: 15th "Building Services, Mechanical and Building Industry Days" : International Conference : Debrecen, ... 15-16 October 2009. Szerk.: Kalmár Ferenc, Kocsis Imre, Csomós György, Csáki Imre, Debreceni Egyetem, Debrecen, 71-76, 2009.

List of other publications

Hungarian book chapter(s) (5)

14. **Kocsis D.**, Bertalan N., Fórián S.: Stratégiai és környezeti zajtérképezés szerepe a műszaki felsőoktatásban =The Role of Strategic and Environmental Noise Mapping in Technical Education.
In: A XX. Fiatal műszakiak tudományos ülésszak előadásai = Proceedings of the XX-th International Scientific Conference of Young Engineers. Szerk.: Bitay Enikő, Erdélyi Múzeum-Egyesület, Kolozsvár, 175-178, 2015.

15. Bertalan N., **Kocsis D.**, Fórián S.: Zajtérképezési vizsgálatok számítógépes modellezéssel =Noise Mapping Examintaions by Computer Modelling.
In: A XX. Fiatal műszakiak tudományos ülésszak előadásai = Proceedings of the XX-th International Scientific Conference of Young Engineers. Szerk.: Bitay Enikő, Erdélyi Múzeum-Egyesület, Kolozsvár, 87-90, 2015.

16. **Kocsis D.**, Princz M., Kozák L.: Természetvédelmi, környezetvédelmi, örökségvédelmi és régészeti adatbázis létrehozása a ZENFE projekt keretében.
In: Proceedings of the Conference on Problem-based Learning in Engineering Education : 10th October 2014. Ed.: Kocsis Imre, University of Debrecen Faculty of Engineering, Debrecen, 86-90, 2014. ISBN: 9789634737612

17. Bodnár I., Boros N., Fehérné Baranyai E., Fórián S., Izbékiné Szabolcsik A., Jolánkai G., Keczánné Üveges A., **Kocsis D.**: Épületek csapadékvizeinek és szürkevizeinek vizsgálata az Észak- Alföld régióban környezetbarát és energiahatékony hasznosítás céljából.
In: Fenntartható energetika megújuló energiaforrások optimalizált integrálásával. Szerk.: Kalmár Ferenc, Akadémiai Kiadó, Budapest, 167-201, 2014. ISBN: 9789630595407

18. Fórián S., **Kocsis D.**, Mezei B.: Csapadékvíz házkörüli hasznosításának lehetősége =Planning of Domestic Rainwater Harvesting System.
In: Fiatal Műszakiak Tudományos Ülésszaka XIX : Nemzetközi Tudományos Konferencia. Szerk.: Bitay Enikő, Erdélyi Múzeum-Egyesület, Kolozsvár, 425-428, 2014.

Address: 1 Egyetem tér, Debrecen 4032, Hungary Postal address: Pf. 39. Debrecen 4010, Hungary
Tel.: +36 52 410 443 Fax: +36 52 512 900/63847 E-mail: publikaciok@lib.unideb.hu, ¤ Web: www.lib.unideb.hu

Foreign language Hungarian book chapter(s) (2)

19. Igaz, T., Lakatos, G., **Kocsis, D.**, Godó, Z.A.: Energy efficiency analysis of an environmentally friendly strawbale insulated house.
    In: XVII. Épületgépészeti, Gépészeti és Építőipari Szakmai Napok : szakkiállítás és Nemzetközi Tudományos Konferencia 2011. október 13-14. : [elektronikus dokumentum]. Szerk.: Kalmár Ferenc, Balla Tibor ; közread. a Debreceni Egyetem Műszaki Kar, Debreceni Egyetem Műszaki Kar, Debrecen, 1-8, 2011. ISBN: 9789634734642

20. Godó, Z.A., Tóth, I., Osváth, G., **Kocsis, D.**, Igaz, T.: Red mud pollution reculvation possibilities.
    In: XVII. Épületgépészeti, Gépészeti és Építőipari szakmai napok : szakkiállítás és Nemzetközi Tudományos Konferencia 2011. október 13-14. [elektronikus dokumentum]. Szerk.: Kalmár Ferenc, Balla Tibor ; közread. a Debreceni Egyetem Műszaki Kar, Debreceni Egyetem Műszaki Kar, Debrecen, 1-10, 2011. ISBN: 9789634734642

Hungarian scientific article(s) in Hungarian journal(s) (4)

21. Godó Z.A., Révész C., **Kocsis D.**: Kompakt fénycső elektromágneses sugárzásának néhány élettani hatása II..
    E-villamos , 1-5, 2011.

22. Godó Z.A., Révész C., **Kocsis D.**: Kompakt fénycső elektromágneses sugárzásának néhány élettani hatása I..
    E-villamos , 1-6, 2011.

23. Godó Z.A., **Kocsis D.**, Révész C.: Az elektroszmog élettani következményei II..
    Villanyszerelők lapja. 10 (4), 16-20, 2011. ISSN: 1588-8770.

24. Godó Z.A., Révész C., **Kocsis D.**: Az elektroszmog élettani következményei I..
    Villanyszerelők lapja. 10 (3), 18-22, 2011. ISSN: 1588-8770.

Foreign language scientific article(s) in Hungarian journal(s) (1)

25. Boros, N., Petrányi, A., **Kocsis, D.**, Bodnár, I.: Characterization of greywater sources on the base of organic content and microbial quality.
    Int. Rev. Appl. Sci. Eng. 5 (1), 35-40, 2014. ISSN: 2062-0810.
    DOI: http://dx.doi.org/10.1556/IRASE.5.2014.1.4

Foreign language scientific article(s) in international journal(s) (1)

26. Mezei, B., Fórián, S., **Kocsis, D.**: The Collectable and Usable Annual Rainwater Amount in the City of Debrecen = Cantitatea de ape pluviale anuale colectabile $_0$si utilizabile din ora$_0$sul Debrecen.
    Acta tech. Napocensis, Environ. Engineer. Sustain. Developm. Entrepreneurship. 3 (3), 11-15, 2014. ISSN: 2284-743X.

Hungarian conference proceeding(s) (3)

27. Godó Z.A., **Kocsis D.**, Kiss G., Stóka G.: Algoritmusalkotó-készség újszerű vizsgálata.
    In: Informatika a felsőoktatásban 2014 konferencia [elektronikus dokumentum]. Szerk.: Kunkli Roland, Papp Ildikó, Rutkovszky Edéné, Debreceni Egyetem Informatikai Kar, Debrecen, 105, 2014. ISBN: 9789634737124

28. Godó Z.A., **Kocsis D.**, Révész C., Pirger Z.: Egyes környezetterhelő neurotoxikus ágensek aktivációja a GST detoxifikációs mechanizmusra.
    In: 16th "Building Services, Mechanical and Building Industry Days" International Conference : 14-15 October 2010 Debrecen, Hungary. Szerk.: Ferenc, ... Csomós György, Csáki Imre, Debreceni Egyetem, Debrecen, 206-213, 2010. ISBN: 9789634734239

29. Berecz G., Dorka G., **Kocsis D.**, Révész C., Godó Z.A.: A környezeti elektroszmog sejtkárosítása és stressztolerancia csökkentése.
    In: 16th "Building Services, Mechanical and Building Industry Days" International Conference : 14-15 October 2010 Debrecen, Hungary. Szerk.: Ferenc, ... Csomós György, Csáki Imre, Debreceni Egyetem, Debrecen, 198-205, 2010.

Foreign language conference proceeding(s) (2)

30. Godó, Z.A., Loós, M., **Kocsis, D.**, Révész, C.: Multiprocessors Parallel Computer for the Signal Processing of Living Nervous System.
    In: IEEE 12th International Symposium on Applied Machine Intelligence and Informatics. [s.n.], [s.l.], 269-274, 2014. ISBN: 9781479934423

31. Godó, Z.A., Dorka, G., Berecz, G., **Kocsis, D.**: Stress tolerance and change of detoxification nearby trivial EM ray source.
    In: XXXX. Membrane Transport Conference : [conference proceedings]. [S.n.], Sümeg, 71, 2010.

Foreign language abstract(s) (1)

32. Godó, Z.A., Révész, C., **Kocsis, D.**: Glutathione - S - Transferase induction effect of red mud contaminated food.
    Acta Physiol. 211 (S697), 140-141, 2014. ISSN: 1748-1708.
    DOI: http://dx.doi.org/10.1111/apha.12362

Total IF of journals (all publications): 2,13
Total IF of journals (publications related to the dissertation): 2,13

The Candidate's publication data submitted to the iDEa Tudóstér have been validated by DEENK on the basis of Web of Science, Scopus and Journal Citation Report (Impact Factor) databases.

14 September, 2015

Address: 1 Egyetem tér, Debrecen 4032, Hungary Postal address: Pf. 39. Debrecen 4010, Hungary
Tel.: +36 52 410 443 Fax: +36 52 512 900/63847 E-mail: publikaciok@lib.unideb.hu, Web: www.lib.unideb.hu