**Autorius:** Tomas Makaras

**Disertacijos pavadinimas:** Daugianarių cheminių mišinių poveikis skirtingų žuvų rūšių elgsenos, fiziologiniams ir biocheminiams rodikliams

**Mokslo kryptis:** Ekologija ir aplinkotyra (N 012)

**Mokslinis vadovas:** dr. Gintaras Svecevičius (2015-2016), dr. Nijolė Kazlauskienė (2016-2019)

**Doktorantūros studijų laikotarpis:** 2015 – 2019

**Gynimo data:** 2019 gruodžio 17 d.

Disertaciją parengė Tomas Makaras. Disertacija rengta 2015–2019 metais Gamtos Tyrimų Centre. Disertacijoje pateikti eksperimentiniai tyrimai apie daugianarių cheminių mišinių (sąvartyno filtrato ir metalų mišinio (Zn, Cu, Cr, Ni, Pb, Cd)), esant subletalioms (realioms) koncentracijoms aplinkoje poveikis skirtingų žuvų rūšių elgsenos, fiziologiniams ir biocheminams rodikliams. Pirmą kartą buvo nustatyti apie aklimacijos sukeltus reofilinių (*Oncorhynchus mykiss* ir *Salmo salar*) ir euritopinių *(Perca fluviatilis* bei *Gasterosteus aculeatus*) žuvų rūšių elgsenos skirtumai, įvertintas modelinių (*O. mykiss*) ir nemodelinių (*S. salar* ir *P. fluviatilis*) žuvų rūšių lokomotorinio aktyvumo ir kvėpavimo reakcijų greitis ir jautrumas bei sukurta ir pritaikyta nauja neinvazinė gliukozės koncentracijos matavimo procedūra tiriant cheminių dirgiklių sukeltas trumpalaikes streso reakcijas žuvyse. Rezultatai parodė, kad aklimacijos trukmė reikalinga skirtingoms žuvų rūšims iki poveikio cheminiais mišiniais yra nevienoda. Žuvų elgsenos ir kvėpavimo reakcijos priklauso nuo SF ir mišinio MIX koncentracijų, poveikio trukmės, žuvų rūšies ir jų amžiaus/dydžio. *Oncorhynchus mykiss* žiaunų ventiliacijos dažnis (ŽVD) jautriausia ir greičiausia žuvų elgsenos reakcija į tiriamų mišinių poveikį. *Perca fluviatilis* elgsenos reakcijos yra mažai jautrios mišinio MIX poveikiui lyginant su modeline rūšimi. Nustatyti reikšmingi gliukozės koncentracijos pokyčiai vandenyje veikiant *O. mykiss* metalų mišiniu.

# **PUBLIKACIJŲ DISERTACIJOS TEMA SĄRAŠAS**

1. Svecevičius G, Kazlauskienė N, Slučkaitė A, **Makaras T** (2014) Toxicological assessment of the effects of closed landfill on neighbouring hydroecosystem. *Fresenius Environmental Bulletin* 23(11a): 2926–2932. Q4 IF = 0.691
2. **Makaras T**, Svecevičius G, Kazlauskienė N, Montvydienė D (2018) Rapid detection of sublethal toxicity using locomotor activity of rainbow trout juveniles. *Bulletin of Environmental Contamination and Toxicology* 100: 221–227. Q3 IF = 1.650
3. Stankevičiūtė M**,** Sauliutė G, **Makaras T,** Markuckas A, Virbickas T, Baršienė J (2018) Responses of biomarkers in Atlantic salmon (*Salmo salar*) following exposure to environmentally relevant concentrations of complex metal mixture (Zn, Cu, Ni, Cr, Pb, Cd). Part II. *Ecotoxicology* 27(8): 1069–1086. Q2 IF = 2.460
4. **Makaras T**, Montvydienė D, Kazlauskienė N, Stankevičiūtė M (2019) Comparison of behavioral and respiratory responses of European perch and rainbow trout to metal mixture in terms of rapidness and sensitivity. *Bulletin of Environmental Contamination and Toxicology*. 103(3): 391–399. Q3 IF = 1.650
5. **Makaras T**, Razumienė J, Gurevičienė V, Šakinytė I, Stankevičiūtė M, Kazlauskienė N (2020) A new approach to stress evaluation in fish using β-D-Glucose measurement in fish holding water. *Ecological indicators.* 109, February 2020, 105829. <https://doi.org/10.1016/j.ecolind.2019.105829>. Q1 IF = 4.490
6. **Makaras T**, Montvydienė D, Kazlauskienė N, Stankevičiūtė M, Raudonytė-Svirbutavičienė E (2020) Juvenile fish responses to sublethal leachate concentrations: comparison of sensitivity of different behavioral endpoints. *Environmental Science and Pollution Research* <https://doi.org/10.1007/s11356-019-07211-6> (priimtas spaudai). Q2 IF = 2.914
7. **Makaras T**, Montvydienė D, Kazlauskienė N (**2019**) Behavioural responses of European perch (*Perca fluviatilis*) and rainbow trout (*Oncorhynchus mykiss*) to exposure of complex (Pb, Zn, Cu, Cd, Ni and Cr). *Proceedings of the 7h International Conference on Environmental Management, Engineering, Planning and Economics*. Mykonos Island, Greece, 90-97. ISBN: 978-618-5271-73-2.
8. Montvydienė D, **Makaras T**, Kazlauskienė N, Cibulskaitė Ž, Šulčius S (**2017**) Ecotoxicity assessment of multicomponent mixtures of different origin (landfill leachate and biomass of harmful algae bloom) using three aquatic organisms*. CEMEPE proceedings of 6th International Conference on Environmental Management, Engineering, Planning & Economics*, Thessaloniki, Greece, 114–123. ISBN: 978-618-5271-15-2.
9. **Makaras T,** Svecevičius G (**2016**) Use of locomotor activity of rainbow trout juveniles identyfing sublehtal concentrations of landfill leachate. *International Journal of Computer and Systems Engineering* 10(1): 15–21.

**Author:** Tomas Makaras

**The title of dissertation:** The effects of multicomponent chemical mixtures on behavioural, physiological and biochemical parameters of different fish species

**Subject area:** Ecology and environmental sciences (N 012)

**Scientific supervisor:** dr. Gintaras Svecevičius (2015-2016), dr. Nijolė Kazlauskienė (2016-2019)

**The period of research:** 2015 – 2019

**Date of defence:** 2019 December 17th

The dissertation, which was prepared by Tomas Makaras at the Nature Research Centre (2015–2019), addresses the problem of understanding and predicting effects of exposure to sublethal (realistic) environmental concentrations of chemical mixtures (landfill leachate and metal mixture) on various biological endpoints in different fish species. This dissertation has provided new scientific data on acclimation-induced behavioural differences between rheophilic (*Oncorhynchus mykiss*, *Salmo salar*) and eurytopic (*Perca fluviatilis,* *Gasterosteus aculeatus*) fish species as well as on differences in behavioural response sensitivity and rapidness of the exposed fish species. A new approach to non-invasive glucose measurement procedure for studying short-term stress responses induced by chemical stimuli in fish has been developed and applied. The results obtained show that the time needed for different fish species to acclimate before actual toxicity testing is variable. Fish behavioural and respiratory responses to exposure depend on concentrations of mixtures, exposure duration, and fish age/size. Gill ventilation frequency was found to be the most sensitive and rapid of all the locomotor and respiratory endpoints examined in *O. mykiss*. This study has revealed that, compared to the model species, *P. fluviatilis* is behaviourally insensitive to metal mixture exposure. Significant glucose level changes induced by metal mixture exposure were recorded in the holding-water of *O. mykiss*.

# **LIST OF PUBLICATIONS OF THE DISSERTATION TOPIC**

1. Svecevičius G, Kazlauskienė N, Slučkaitė A, **Makaras T** (2014) Toxicological assessment of the effects of closed landfill on neighbouring hydroecosystem. *Fresenius Environmental Bulletin* 23(11a): 2926–2932. Q4 IF = 0.691
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4. **Makaras T**, Montvydienė D, Kazlauskienė N, Stankevičiūtė M (2019) Comparison of behavioral and respiratory responses of European perch and rainbow trout to metal mixture in terms of rapidness and sensitivity. *Bulletin of Environmental Contamination and Toxicology*. 103(3): 391–399. Q3 IF = 1.650
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