

**HISTORY OF INTERNATIONAL PARTNERSHIP - SCIENTIFIC PRIORITIES
AND EDUCATIONAL ACTIVITY OF PROFESSOR TSITSINO TURKADZE**

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Abstract. The article describes the main stages of professional work, scientific priorities, and educational activities of Professor Tsitsino Turkadze. The main results of joint research with a special international consortium for coordination of similar research on municipal solid waste management - determining the waste composition as function of economic, social, and seasonal changes; assessing future material and

contaminant flows, considering different scenarios; quantifying and assessing the material resources and reserves from landfills. The article discusses the educational activities carried out in the high school to implementing modern research results in higher education programs and teaching.

Keywords: Industrial Dust, Municipal Solid Waste (MSW) Generation, MSW composition, landfill mining (LFM), rare Earth elements (REEs), Anthroposphere Excavation, resource potential of landfill waste, Climate Management.

Tsitino Turkadze, Professor, Doctor of Technical Sciences at Department of Chemical and Environmental Technologies of Akaki Tsereteli State University (ATSU). She was born on May 12, 1971 in Kutaisi, Georgia.

After the collapse of the Soviet Union and Georgia's recognition of independence in 1991, the country's education system also demanded the decisions needed to function independently. The growth of engineering staff in Georgian higher education institutions was limited because it was subject to Soviet Union regulations and was mostly located in large Russian universities. Georgian higher education institutions have started to form postgraduate departments and offer technical doctoral degree programs for young people at the national level.

Such historical preconditions were when in 1992, a postgraduate course was opened at Kutaisi Technical University, in which one of the specialties was environmental protection and rational use of natural resources. In the same year, on the basis of a competition announced for this specialty, the university, on the basis of a competition announced for this specialty, young people were enrolled in the university, including Tsitsino Turkadze, a graduate of the same university qualified as an engineer-chemical-technologist.

The research topic of Tsitsino Turkadze's postgraduate study period was related to the current environmental challenges of Georgia and included the study of Industrial Dust of the Basic Enterprises of Georgia with a Choice of Dedusters. Georgian enterprises, especially in heavy industry, worked on local mineral raw materials (coal, manganese ore, ferroalloys, limestone and sand), as a result of which the physical and chemical properties of the emitted dust were important information for the selection of dust collection systems. Based on the study of dust released in different parts of Georgian industrial enterprises, a special atlas was created, which gathered information on the dispersive composition, physical (such are bulk density, abrasion, electrical resistance, liquidity) and chemical properties (pH, chemical composition) of dust. Using this information, a special software code was developed, which was used to calculate the efficiency of the selected dust collection system. In 1997, the Scientific Council of Tbilisi State University approved the submitted paper and awarded the author the degree of Candidate of Technical Sciences.

While working at the department of Chemistry of Kutaisi Niko Muskhelishvili State University in 2001-2006, a group of scientists focused on the synthesis of new complex compounds of metals, the study of ways in which metals accumulate in environmental components and food products (Ambroladze, et al., 2008). Studies in this area have shown ways to get heavy metals into agricultural products produced in Georgia, such as grapes, wine and its products. Air pollution caused by vehicle emissions has affected the ecological cleanliness of the grapes grown in the roadside and off-road areas.

Involvement in the implementation of higher education programs and educational activities allowed of Prof. Tsitsino Turkadze to conduct some methodological research on environmental education issues. Some aspects of teaching problems and methods of chemical pollution and integrated waste

management in high school (in a bachelor programme) were discussed in publication of Georgian Electronic Scientific Journal: Education Science and Psychology (Turkadze et al., 2007; Turkadze, Bochoidze, 2008).

In 2006, as a result of the accession of the Georgian educational space to the Bologna Process, the process of developing bachelor-master-doctoral programs began. Akaki Tsereteli State University (ATSU) started its bachelor's program in Environmental Engineering and Applied Ecology in 2011. It was headed by Prof. Tsitsino Turkadze. Later in 2012, under his leadership, an accredited master's program in environmental engineering was launched, as well as a doctoral program in environmental engineering, co-supervised by Professor Gintaras Denafas, from Kaunas University of Technology (Lithuania).

In 2009, the Eurasia Partnership Foundation funded the project "Monitoring and Improvement of Cleaning Service in Kutaisi Through Strengthening Civil Society Participation", where Professor Tsitsino Turkadze participated as an Expert of Environmental Protection. Since 2009, in the field of scientific research, following in the footsteps of local environmental challenges, the issues of solid waste management and composition research have gained urgency. As a result of international cooperation in 2009-2010, a research proposal prepared by a group of scientists on the composition of municipal solid waste research won funding from the Swiss National Scientific Foundation, therefore international project "Seasonality of Municipal Waste Generation and Composition and Corresponding Fluctuations of Various Environmental Indicators for Waste Management and Treatment Facilities" – SWC-ENV-IND (2010-2014) was held with research groups from Switzerland, Russia, Lithuania, Ukraine and Georgia. The research was coordinated by the Swiss Federal Institute of Technology at Lausanne with the support of Paul Scherrer Institute (Switzerland). In this SWC-ENV-IND project team consists of Kaunas University of Technology (Kaunas, Lithuania), Akaki Tsereteli State University (Kutaisi, Georgia), united research group of Kyiv National T.S. University, Ukrainian State Technical University "Kyiv Polytechnic Institute", National Taras Shevchenko University of Kyiv (Kyiv, Ukraine). Moreover, the project team has been complemented with a special international consortium for coordination of similar research. This consortium unites of East European Universities and Estonian University of Life Sciences (Tartu, Estonia), Lappeenranta Technological University (Finland),

Linnaeus University (Kalmar, Sweden) and Aristotle University Thessaloniki (Thessaloniki, Greece).

The SWC-ENV-IND project had two main scientific tasks: 1) Determining the waste composition as function of economic, social, and seasonal changes. 2) Predicting and assessing future material and contaminant flows (e.g., heavy metals), considering different scenarios. Possible scenarios would be a) continuation of landfilling, b) replacing landfilling by mechanical-biological treatment and/or incineration, and c) combined treatment with an improved separate collection system, like the one in Switzerland.

The SWC-ENV-IND project research methods included three main modules: Module 1. Waste management systems, waste composition, first seasonal data - Comparison of waste management system and waste composition with similar data from other countries. Module 2. Waste composition study considering seasonal changes using appropriate methodologies. Module 3. Material flow analysis, assessment, and predictions - Development of methods and models for estimating and forecasting material flows considering various social, economic, and technological factors.

The composition of municipal solid waste (MSW) is important to obtain more information about the waste composition to establish adequate collection systems. However, MSW is a result of regional and cultural aspects as well as social behavior, and it is strongly influenced by economic factors. Eastern Europe (EE) suffer with a lack of well-developed separate collection systems for recyclable materials. Random sorting actions do not provide sufficient information because of strong seasonal fluctuations in MSW composition, therefore project partners started to improve the current data basis aiming to develop a methodology to investigate, evaluate and predict seasonal MSW composition for EE countries.

In different countries, MSW analyses methods are slightly different. To unify the entire work group MSW investigation unified methodology has been developed: “Methodology for Determination of the Composition of Unprocessed Municipal Solid Waste and Waste Composition Dependence from Regional Social-Economic and Climate Characteristics”. This methodology is based on some Standard Test Methods for Determination of the MSW (LST CEN/ISO 14780 „Solid biofuels – Method for sample preparation”; ASTM D 5231 – 92 „Standard Test Method for Determination of the Composition of Unprocessed MSW”; ASTM D 4687 – 95 „Standard Guide for General Planning of Waste Sampling”) and Kaunas

University of Technology Municipal Solid Waste research experience.

In 2009-2011, under the leadership Prof. Tsitsino Turkadze MSW composition has been investigated in Kutaisi city (Georgia), in collaboration with local firms on management of waste. For 10 days in each month sorting of waste according to the mentioned methodology has been implemented. The results of investigations are utilized to obtain scientific knowledge necessary to understand waste generation and composition, to gain basic information which is needed to avoid future emissions to the environment resulting from current waste treatment practice, as well as to plan improved separate collection systems in combination with landfilling, mechanical-biological treatment and / or incineration (Turkadze et al., 2007; Turkadze, Bochoidze, 2008).

The key factor describing the suitability of waste for incineration is its calorific value. Based on fractional content of recyclable organic matter and MSW humidity, the calorific value of combustible components was calculated. Seasonal changes MSW calorificity in Kutaisi city, in 2010–2011 (Georgia) fall within the range of 7–10 MJ·kg⁻¹, the lowest in July – 7.2 MJ·kg⁻¹, the highest in March – 9.7 MJ·kg⁻¹. According to the obtained data, assessment of current and future incineration was also performed by selecting and using appropriate forecasting models (Denafas et al., 2010).

The SWC-ENV-IND project has made a significant contribution to launching a study on the seasonality of municipal waste generation, waste recycling and various environmental indicators of wastewater treatment plants in Georgia. MSW composition investigation in Kutaisi (Georgia) are utilized in the following chapters of Kutaisi MSW management final report: Recommendation for Improvement of Waste Collection; Structure of Performance Monitoring System; Waste Composition and Recycling potential; Recommendation for Recycling; Staged Approach for Implementation of Recycling; Rehabilitation and Closure of the Existing Kutaisi Disposal site; Rehabilitation measures of old landfill. During the reporting period the scientific achievements of the project have been presented at conferences and scientific seminars, and as publications in scientific journals (Turkadze, Bochoidze, 2011; Denafas et al., 2011; Mikhaylenko et al., 2011; Denafas et al., 2014).

With framework SWC-ENV-IND international consortium international scientific conferences and seminars were held in Kiev (Ukraine) – International Scientific and Practical Conference “Sustainable

Municipal Solid Waste Management In Eastern Europe – Future Perspectives” -2011; in Kutaisi (Georgia) – International Scientific–Practical conference “Innovative Technologies and Environment Protection”- 2012; in Kaunas (Lithuania) – International seminar “Landfill mining in the context of global environmental mitigation”- 2014. The SWC-ENV-IND project research team was in close contact with scientists from Sweden, Estonia and Latvia to study issues related to the management of old landfills and the use of their resource potential. The concept presented at the international seminar “Landfill mining in the context of global environmental mitigation” in 2014 at department of Environmental Technology, Kaunas University of Technology (Lithuania), and further scientific research carried out concerned to the landfill mining (LFM).

LFM approach can deal with former dumpsites and this material may become important for circular economy perspectives within the concept “Beyond the zero waste”. Real-time applied LFM projects in the Baltic Region have shown the potential of fine-grained fractions (including clay and colloidal matter) of excavated waste as storage of considerably large amounts of valuable metals and rare Earth elements (REEs). Analytical screening studies have extended a bit further the understanding of fine fraction contents of excavated, separated and screened waste in a circular economy perspective (Burlakovs et al., 2016; Burlakovs et al., 2017). LFM constitutes an important technological toolset of processes that regain resources and redistribute them with an accompanying reduction of hazardous influence of environmental contamination and other threats for human health hidden in former dump sites and landfills. the study is presented in a scientific article “Paradigms on landfill mining: from dump site scavenging to ecosystem services revitalization” (Burlakovs et al., 2019).

In 2015, a group of scientists, led by Prof. Kral Ulrich (Austrian University of Technology), developed an application for the Horizon 2020 program – European Cooperation in Science and Technology (COST), with the project title: European Anthroposphere Excavation – MINEA (2015-2020). With this project was established the pan-European Expert Network on Mining the European Anthroposphere (MINEA) with stakeholders from more than 32 countries, that aims to initiate the classification of Anthropogenic Resources. The MINEA project works in three main areas: 1. Resource

potential of construction and demolition waste; 2. Resource potential of waste from landfills; 3. Resource potential of solid residues from waste incineration. As a scientist from the Eastern Partnership countries, Prof. Ts. Turkadze was involved as MC Observer from COST Near Neighbor Countries in a working group working on research into the resource potential of landfill waste. Within of MINEA project was quantified and assessed the material resources and reserves in the Anthroposphere and consolidated existing knowledge related to the exploration, evaluation, classification, and recovery of materials in anthropogenic deposits and waste flows. This information is essential to assess the availability of secondary material from landfills and the viability of landfill mining projects in the context of circular economy.

These research results and new approaches were new to the scientific and administrative field of Georgia; therefore, the dissemination of research results was useful information for future decision-making and sustainable development in EE countries, not only for Georgia but also for the countries of the Caucasus region.

Participating in various projects (as an environmental expert) funded by the Black Sea Program with co-financed by the European Union was a good opportunity for Prof. Ts. Turkadze to share modern approaches to waste management with the people of the Caucasus region, the non-governmental sector and government officials. There are projects: International project Introduction of innovative waste management practices in selected cities of Georgia, Moldova, and Armenia (2013-2014); International project “Joint solution of the same problems: improvement of municipal waste management services in Ijevan (AM) and Bolnisi (GE)” (2015–2016); International project “Waste Free Rivers - Clean Black Sea” (2018-2020).

Implementing modern research results in higher education programs and teaching is one of the most important issues. Various activities in this direction play an important role in work of Prof. Ts. Turkadze. In this direction work is also actively underway within the framework of international projects. These are the projects funded by the Swedish Institute under the Baltic Sea Partnership: “Strengthening the Baltic University's Network on Landscape Sustainability and Waste Management” - LASUWAMA (2018-2020)

and “Knowledge in Inter Baltic Partnership Exchange for Future Regional Circular Economy Cooperation - PECEC (2017-2019). One of the goals of these projects is to develop training courses and research results to integrate them into teaching in accordance with modern teaching methods (Mykhaylenko et al., 2018; Turkadze et al., 2018; Turkadze, 2021).

From 2011 to present, as an Accreditation Expert for Higher Education Programs, Prof. Tsitsino Turkadze participates in the activities of the Georgian National Center for Educational Quality Enhancement, that works for the purpose to ensure compliance with European Higher Education Area, on improving external and internal quality assurance mechanisms, its implementation, creation of relevant recommendations and supports creation and development of educational programs.

Since 2020, as the head of the Master of Environmental Engineering program at ATSU, Prof. Tsitsino Turkadze has been involved in Erasmus + Capacity Building in Higher Education project “Synergy of educational, scientific, management and industrial components for climate management and climate change prevention/CLIMAN”, that aims to help the partner UA and GE universities to become centers for the development of research of climate management to accelerate integration into the global climate market and to meet global climate regulation requirements by acquiring best European practices in the field of climate change prevention, adaptation and mitigation.

At the current stage within the CLIMAN project Prof. Tsitsino Turkadze leads work related to update the existing master degree programs by developing an interdisciplinary training module “Climate Management”, establish consulting Climate Management Centers at ATSU and ensure their sustainable development; Facilitate the development and strengthening of institutional capacity of ATSU aiming to develop recommendations for the industrial, transport, energy, tourism sectors and local authorities in the sphere of climate change prevention, adaptation and mitigation.

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