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LETTER

From Afar and From the Inside: About the Importance of Ethics in the Global World of Science

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"From afar, that is, from my homeland, Poland, perhaps showing to some extent the point of view of a European; from the inside, that is, by being a regular visitor in Brazil and having many personal contacts with Brazilian analysts".

Before I share my thoughts on the ethical responsibility of science, especially analytical chemistry, I would like to emphasize how much I appreciate the high level of analytical chemistry in Brazil. I am also impressed by the number of young people passionate about analytical chemistry. This includes the development of novel analytical procedures and their use to solve several current problems of humanity.

Ethical Dimensions in Analytical Chemistry

In today's rapidly evolving world, characterized by technological advancements and global interconnectedness, the importance of ethics cannot be overstated. Measurements of chemical quantities, i.e., primarily the content of several substances (chemical compounds, ions, elements, and their isotopes) support many important decisions in science, business, and law-making. Responsibility for the measurement results lies with the analyst, regardless of the country in which the measurements are conducted, no matter how modern the device used is, and no matter how urgent the results are.

The problem of responsibility for measurement results is very much discussed in my homeland and in Polish laboratories - both academic and commercial - the attention to the quality of results is very high. Therefore, I think it will be of value if I share with the readers of the Brazilian Journal of Analytical Chemistry some thoughts on ethical considerations in analytical chemistry. In particular, I would like to draw attention to key issues such as data integrity, reproducibility, responsible conduct, and the implications for scientific research and societal trust.

Challenges and Solutions in Research Integrity

The main effect of analytical chemistry is the generation and interpretation of data, whether from scientific research or routine measurements. The integrity of this data can be compromised by various factors including human error, equipment malfunction, or even deliberate manipulation. Ensuring data integrity requires rigorous adherence to established protocols, focusing on great care for record-keeping, and transparent reporting practices. Moreover, analytical chemists must guard against the temptation to intentionally select data to fit the hypothesis or the temptation to influence results. By upholding principles of honesty and accountability, we not only safeguard the integrity of our research but also uphold the trust placed in our findings by the scientific community and society at large.

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Let's look at the challenges related to reproducibility in analytical chemistry research. Factors such as experimental variability, methodological differences, and publication bias can contribute to challenges in replicating research findings. Addressing this requires a concerted effort from researchers, peer reviewers, journal editors, and funding agencies. Analytical chemists can contribute to this effort by adopting rigorous validation procedures, openly sharing data and methodologies, and encouraging collaboration and replication studies.

Ethical conduct extends beyond our laboratory practice and the results we obtain. Analytical chemists must adhere to ethical codes of conduct, respect the rights and dignity of research subjects, and disclose any potential conflicts of interest. We have a duty to communicate our findings accurately and responsibly, avoiding sensationalism or exaggeration that could mislead the public, the media, or policymakers. This may concern public health risks, environmental harm, and economic foundations of running a business, trade, or issuing court judgments.

The Brazilian Meeting on Analytical Chemistry's Commitment to Better Ethics

My good experience is that as part of the Brazilian Meeting on Analytical Chemistry conference, many presentations are devoted to the development of innovative analytical procedures, which often lower the detection limits of a given substance and increase the chromatographic resolution, allowing for the identification of new chemical compounds; some focus on simplifying the measurement procedure allowing for a reduced consumption of often toxic reagents, i.e., a nod to green chemistry.

These are usually well-documented studies that open new research perspectives. However, we must remember that the application of these procedures in practice requires considering not only the opinions of the scientific community but also the legal acceptance of regulators. These may include codes of conduct, ethical review boards, and mechanisms for investigating allegations of misconduct.

Case Studies of Ethical Dilemmas in Analytical Chemistry

We are all aware that many important decisions depend on measurement results. Take the climate crisis, for example. On the one hand, we have a catalogue of validated procedures enabling ongoing monitoring of selected parameters that reflect the status of the environment. In this case, the responsibility of the analyst includes using appropriate chemical standards for calibration and matrix reference materials to assess the accuracy of results, not to mention ongoing quality control. On the other hand, we are working on improving well-established procedures so that it is possible to evaluate new indicators of environmental pollution.

Now, to illustrate the real-world implications of ethical considerations in analytical chemistry, let us consider a specific case: a research team publishes ground-breaking findings on the detection of a new environmental contaminant, however, their results were called into question due to inconsistencies in their data. Upon further investigation, it was revealed that certain data points were selectively omitted or manipulated, raising concerns about the integrity of the research.

In a similar vein, one can mention clinical trials that affect each of us, our relatives and friends. The results of measurements of clinical parameters are used by medical doctors to decide on the status of our health. There is a known case of a patient with glomerulonephritis who was being prepared for immunosuppressive therapy. The dose of the pharmaceutical was selected based on the measurement of the protein content in urine collected within 24 hours. One day, the patient's family poured the collected urine into several containers and gave the samples to various laboratories. How surprised the attending medical doctor was when he received significantly different results from those individual laboratories. And this turned into a dilemma as to what decision he should make regarding immunosuppressive therapy. In another case, a pharmaceutical company was accused of suppressing unfavorable analytical data on the safety of a new drug, raising ethical questions about transparency and public health. Similar examples are numerous.

Another area that is also sensitive is food, where ethical considerations apply, for example, to marking the nutritional value of a given product. I often cite the example of research conducted in one of the university laboratories in Poland, where the content of water-soluble salts in freeze-dried raw potatoes was determined. On this basis, it was assessed which variety would be best for introduction into cultivation. Very modern measuring equipment was used, many repetitions were made, and the results were evaluated using very advanced chemometric procedures. But all it took was a simple question from a nutrition specialist who asked why potatoes were not tested after cooking, meaning exposed to hot water extraction, as it is known that in Poland most of us eat boiled potatoes. Therefore, knowledge about the content of nutrients in freeze-dried raw potatoes is certainly not worth the research being conducted.

The subject of forensic testing is also worth mentioning, especially when it is necessary to check the administration of toxic substances. Collecting evidence about the "chemical weapon" of a crime or a prohibited act can enable the authorities to reconstruct the event and, consequently, can be used as forensic evidence to decide whether to convict or acquit a person. In the case of doping tests in sports, the consequence may be the temporary disqualification or the complete termination of the career of the athlete concerned.

Education and Ethics in Analytical Chemistry

As part of the ongoing discussion on analysts' responsibility towards society, I view education as an important part of this game. Having had many inspiring discussions with my Brazilian friends, I appreciate our common understanding of the issue of the importance of incorporating ethics education into analytical chemistry curricula and professional development programs to foster a culture of ethical awareness and responsibility.

As a consequence of the implementation of legal regulations related to the need to perform a variety of chemical measurements, the number of testing laboratories performing measurements, and the number of people employed in them has increased significantly in recent years. It is now largely up to us academics to ensure that our students, the future laboratory workers, carry the spirit of responsibility for their actions.

I have always felt personally responsible for my student's development and integrity, aiming for such responsibility and the need for ethical behavior to be something obvious for them, something natural, something necessary also in realizing their own ambitions. I try to inspire my students to reflect on the fact that the ethical implications of analytical chemistry go beyond the laboratory and have far-reaching implications for society. As already highlighted, the accuracy and reliability of analytical data can have profound implications for public health, environmental protection, and regulatory decision-making. Ethical lapses in analytical chemistry, such as data manipulation or fraudulent practices, can erode public trust in science and undermine confidence in regulatory processes. At the end of the day, accountability dictates that each of these problems be reduced by the personal responsibility of the person who provides the data and knowledge that influences decisions.

In conclusion, it's crucial to underscore the central role that ethical considerations play in analytical chemistry. They not only shape our research methodologies but also guide our professional demeanor and influence our societal engagement. As guardians of scientific integrity, we must firmly uphold ethical standards and foster a culture of integrity both within and beyond our field.

Ethical responsibility in the realm of analytical chemistry is not confined by geographical boundaries. Whether in Poland, Brazil, or any other corner of the globe, analysts must recognize and embrace this responsibility wholeheartedly. Personally, I take immense pleasure in collaborating with the vibrant Brazilian analytical community, particularly in witnessing the growing involvement of women who bring innovation to the field while championing accountability for their findings, thus emphasizing the ethical underpinning of scientific inquiry.

It's a privilege to engage in collaborative endeavors with analysts from diverse research groups in Brazil. Our shared commitment to upholding ethical principles and advancing social responsibility sets a high benchmark for our collective endeavors in the pursuit of scientific integrity.

Prof. Dr. Ewa Bulska graduated from the University of Warsaw and is continuing her work as a Professor of Analytical Chemistry and Director of Biological and Chemical Research Centre at the University of Warsaw. She is an elected member of the Analytical Chemistry Committee of the Polish Academy of Sciences and chairwoman of the Atomic Spectrometry Group of the Polish Academy of Sciences, member of the Polish Chemical Society, vice-president of the Polish Research Laboratories Club POLLAB, member of the board of the international organization EUROLAB. In the years 2017 – 2022, she chaired the Metrology Council of the Central Office of Measures. She is also the chairwoman of the Program Council of the MALAMUT publishing house.

She was awarded a fellowship at Max-Planck Institute für Metallforschung, Germany; visiting scientist fellowship at the University of Umea, Sweden; DAAD fellowship at the University of Darmstadt, Germany. She received a number of awards, including the Bunsen-Kirchhoff Prize awarded by the German Chemical Society (2004); W. Świętosławski University of Warsaw awards (2006); Wiktor Kemula Medal awarded by the Polish Chemical Society (2012); and the Jerzy Fijałkowski Award by the Committee of Analytical Chemistry of the Polish Academy of Sciences (2016). She was also awarded the Golden Cross of Merit and the Knight's Cross of Polonia Restituta. She was included by the International Union of Pure and Applied Chemistry (IUPAC) among most outstanding women chemists, and she was awarded the title of IUPAC'2015 Distinguished Woman in Chemistry. She works actively in various non-profit organizations and is a member of the Executive Committee of the Marie Skłodowska-Curie Society.

Her scientific interest covers the area of the metabolism of biologically active substances, including speciation, proteomics, and metabolomics as well as the investigation of cultural heritage objects. She also contributed to the development of various new analytical methodologies and procedures. She participates in various activities related to metrology in chemistry and the quality of measurement results, including her activities in developing certified reference materials for the purposes of environmental monitoring, for food sector issues, as well as forensics sciences.

Professor Dr. Ewa Bulska is an author or co-author of over 240 scientific publications in international journals resulting with h-index 37; she contributed to several textbooks and monographs in Polish and international publishing houses.