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## EXAMINATION OF THE ACCREDITATION STATUS OF WATER QUALITY PARAMETERS

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### ABSTRACT

#### Introduction

The monitoring of pollutant concentrations resulting in water pollution, which constitutes the basis of environmental pollution, and the measurement of the water parameters used in pollution control must be done in the accredited laboratories in order to get more reliable results.

#### Aim of the study

To examine and compare the accredited laboratories of universities, public institutions and private sector in Turkey with regard to water quality parameters. To eliminate the deficiencies in the literature.

**Material and methods.** We studied on 47 water quality parameters. The data in this study were taken from Turkish Accreditation Agency (TURKAK-Türk Akreditasyon Kurumu) website. There exist only 10 universities having accredited laboratories in terms of water quality parameters in Turkey. Furthermore, 11 public institutions and 71 private sectors in Turkey have accredited laboratories related to environmental quality parameters. The most remarkable accredited water parameters are considered and the frequencies according to these parameters are calculated.

**Results.** University laboratories are examined in terms of 42 water quality parameters. The universities which have the most accredited laboratories with regard to water quality parameters are Dokuz Eylül University and Mugla Sıtkı Kocman University, respectively. All of

the public institutions are accredited both in environmental parameters and all water quality parameters, while the private institutions are only accredited in environmental parameters without accreditation in water quality parameters. Of the private establishments with accredited laboratories, only 44 are accredited in terms of water quality parameters.

### Conclusions

Findings show that the number of institutions with accredited laboratory in Turkey is very inadequate.

**Key words:** water quality parameters, ISO 17025, laboratory accreditation.

### INTRODUCTION

While accreditation term can be described as a process in which competency, authority or credibility is certified (1), certification can be defined as a procedure by which a third party provides written assurance that a product, process or service conforms to specific requirements. Certification is not a guarantee for quality, it solely refers to written procedures (2). Accreditation should be separated from certification of quality systems, because it associates with the assessment not only of quality systems but also the technical competence. Accreditation is handled both in laboratories and in all bodies playing role on the conformity assessment functions such as, calibration, testing, certification of quality systems (ISO 9000), certification of environmental management systems (ISO 14000), certification of products, and certification of personnel as well as inspection (3). International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) issued the ISO/IEC 17025 international quality standard, which combines all of the essential requirements for testing and/or calibration laboratories to verify their technical competence and validity of the data and outcomes they generate (4). ISO 17025 is a laboratory standard equivalent to more general ISO 9000. The standard can be applied by all organizations performing tests and/or calibrations and it can harmonize laboratories worldwide (5;6). Documenting of the process of any analysis performed by a laboratory consists of key point of ISO 17025, as all ISO standards. ISO17025 combines the quality management system and technical needs of the accreditation process. The management requirements section of the standard assesses the organization of the laboratory; its quality system; document control; review of requests; tenders and contracts; subcontracting of tests and calibrations; purchasing services and supplies; service to the customer; complaints; control of nonconforming testing and/or calibration work; corrective actions; preventive actions; improvement; control of records, internal audits and management reviews. This section adapts the ISO 9000 quality management criteria into a laboratory context. The technical requirements section of the ISO 17025 standard evaluates personnel; accommodation and environmental conditions; test and calibration methods and method validation; equipment; measuring traceability; sampling; handling of test and calibration items; assurance of the quality of test and calibration results, and reporting the results. A laboratory must identify both the management requirements and technical requirements of the standard in order to generate a good product and satisfy its customer (5;7). Laboratories having ISO/IEC 17025 accreditation are superior than others due to some advantages presented below:

- Increasing the quality awareness, greater efficiency and better teamwork
- Enhancing the credibility, confidence and reliability of the measurement results
- More elaborate and detailed reports received from customers lead to increased satisfaction
- Suitability and traceability of calibration, measurements and maintenance of test equipment to international standards
- Ease and clarity of handling the records and documentation of the quality system.

Also, accreditation has some disadvantages:

- The high cost, which consist of the cost of building the system, the cost of calibration the device and its accessories, the cost of compliance with environmental conditions, the cost of personnel training, the cost of updating standards, the cost of maintaining the system application and the cost of periodic re-assessment and renewal of the certificate.
- The time-consuming efforts, increased documentation and system bureaucracy contribute to labor intensification which in turn leads to a decrease in job satisfaction (4).

Accreditation of test and calibration laboratories in Turkey was made by TURKAK. It is sole national accreditation body established by law (Nr. 4457) to evaluate competence towards internationally recognized standards of organizations that offer certification, testing, inspection and calibration services. Establishment law of TURKAK was approved in November 1999. Before its establishment, there were no accreditation authorities to comment conformity assessment services in Turkey. TURKAK has been playing an important role on confirmation and evaluation of accreditation status of calibration and testing laboratories since July 2002 (8). Turkey in the process of conformity to the European Union has been demanding laboratory services in especially some areas as environmental safety, the control of renewed food, healthcare every passing day (9). Laboratory is accredited by internationally accredited accreditation bodies for the acceptance of laboratory results at the national and international level. This process is generally based on voluntary procedure (10).

Some of water sources found as the fundamental natural resources in the world can be listed as rivers, lakes, glaciers, rain water, ground water etc. It is easily said that water has been employed for various aims such as, drinking, agricultural activities, livestock production, forestry, industrial activities, hydropower generation, fisheries and other activities (11). Water pollution is one of the most remarkable global environmental issues of the 21<sup>st</sup> century (12). When soil is disturbed for urbanization, rain and snow melt events pick up pollutants and toxic substances from anthropogenic activities and distribute them into water resources (12; 13). Pollutant discharge into water resources results in eutrophication and severe ecological destruction due to extensive organic pollution and toxic pollution (14). Hence, water polluting owing to pollutant discharge can have undesirable effects on aquatic life, habitats and public health (13). There is a relationship between water pollution and water-borne diseases such as, hepatitis, cholera, dysentery, cryptosporidiosis, giardiasis, diarrhea and typhoid. Also, it was found that water pollution can trigger carcinogenic diseases (14). The most appropriate step to be applied to minimize the negative effects of water pollution and to determine pollutant factors and dimensions of pollution is water quality monitoring (15). The monitoring of pollutant concentrations that cause water pollution and the measurement of the water parameters used in pollution control must be done in the accredited laboratories proving that test and analysis results are reliable by third parties and institutions.

In this study, university, public institution and private laboratories accredited in the measurement of environmental parameters were examined in Turkey, and the accreditations of these institutions were compared in terms of environmental water parameters. There are a lot of articles related to the implementation and accreditation of ISO/IEC 17025 in various areas, but directly there is no article in the literature deal with this topic. Therefore, this study will, hopefully, contribute to filling this gap. It is aimed to eliminate the deficiencies in the literature thanks to this study.

## MATERIALS AND METHODS

Monitoring and evaluation of water quality are needed for the improvement of water resources polluted by agricultural and/or industrial activities and for the protection of natural water resources. Therefore, measurements of water quality parameters should be made regularly (16; 17).

In this study 47 water quality parameters were examined. These parameters are pH, Conductivity, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Dissolved Oxygen (DO), Hardness, Temperature, Color, Alkalinity, Ammonia/Ammonia Nitrogen, Calcium (EDTA Method), Chlorophyll, Residual Chlorine, Chloride, Chromium<sup>+6</sup>, Magnesium, Nitrate/Nitrate Nitrogen, Nitrite/Nitrite Nitrogen, Light Transmittance, Total Solid (TS), Suspended Solid (SS), Ammonium/Ammonium Nitrogen, Total Nitrogen, Total Kjeldahl Nitrogen (TKN), Phosphate/Orthophosphate Phosphorous, Total Phosphorous, Sulfate, Escherichia coli (E. coli) and Coliform Bacteria Count, Total Dissolved Solid, Oil-Grease, Turbidity, Total Organic Carbon, Arsenic (As), Cadmium (Cd), Lead (Pb), Iron (Fe), Copper (Cu), Calcium (ICP-MS Method), Zinc (Zn), Aluminum (Al), Manganese (Mn), Nickel (Ni), Silver (Ag), Sodium (Na), Potassium (K).

The data in this study have been taken from TURKAK web site. In the study, accredited university laboratories, public institution and private laboratories were examined with regard to accredited water quality parameters. As of the academic year of 2015-2016 in Turkey, there are totally 190 universities including 114 public and 76 private universities. Only 10 of the universities in Turkey have accredited laboratories where water quality parameters are measured. These universities are Ağı Ibrahim Cecen University, Anadolu University, Balıkesir University, Bogaziçi University, Dicle University, Dokuz Eylül University, Kahramanmaraş University, Mersin University, Muğla Sıtkı Kocman University, Trakya University. Furthermore, 11 public institutions and 71 private sectors in Turkey have accredited laboratories in the measurement of environmental quality parameters. These public institutions are The Scientific and Technological Research Council of Turkey (TUBITAK), Antalya Water and Sewage Authority General Directorate (ASAT), Denizli Metropolitan Municipality, Antalya Metropolitan Municipality, Kayseri Metropolitan Municipality, Ministry of Environment and Urbanization, İzmir Water and Sewage Authority General Directorate (IZSU), İstanbul Environmental Management Industry and Trade Company (ISTAC), Muğla Water and Sewage Authority General Directorate (MUSKI), İstanbul Metropolitan Municipality, MUSKI Bodrum Environmental Laboratory.

## RESULTS

The development of a wide-ranging quality management system (QMS) is a time-consuming process, needing organization, motivation and investment (18). QMS has to be identified in the Quality Manual. It also has to include fundamental procedures and has to be simple. Items to be found in the quality manual of a medical laboratory are introduction, description of medical laboratory, quality policy, staff education and training, quality assurance, document control, records, maintenance and archiving, accommodation and environment, instruments, reagents and consumables management, validation of examination, safety, environmental aspects, research and development, list of examination procedures, request protocols, primary sample, collection, and handling of laboratory samples, validation of results, quality control, laboratory information system, reporting of results, remedial actions and handling of complaints, communication and other interactions with patients, health professionals, and internal audits as well as ethics. Quality manual of a laboratory measuring environmental parameters is similar to that of a medical laboratory mentioned above (19). Quality credibility is a system of activities that provides metrics that meet certain quality standards at an acceptable level of confidence. With untrustworthy data, it is not possible to make healthy decisions to reduce water pollution.

Making measurements that could not meet the data quality objectives will bring about unnecessary resource waste. For this reason, in the measurement of environmental parameters, laboratories accredited with ISO 17025 standard should be preferred in order to realize quality reliability (20).

The current status of the water quality parameters of the universities having accredited laboratories in Turkey are shown in Table 1. University laboratories have examined in terms of 42 water parameters. Water parameters that universities laboratories are not accredited are TS, Ammonium/Ammonium Nitrogen, Ammonia/Ammonia Nitrogen, Total Nitrogen and TKN, respectively.

**Table 1. Examination of the accreditation status of accredited university laboratories in terms of water parameters**

University	Number of accredited quality parameters
Dokuz Eylul	41
Mugla Sitki Kocman	30
Anadolu	22
Bogazici	20
Trakya	14
Balikesir	11
Kahramanmaras	8
Agri Ibrahim Cecen	5
Mersin	4
Dicle	2

According to Table 1, accredited university laboratories in the most of water quality parameters are Dokuz Eylul University and Mugla Sitki Kocman University, respectively. Dokuz Eylul University laboratories were not accredited by only one of the 42 water parameters studied. This parameter is temperature. In addition, pH and conductivity parameters accredited in most of the university laboratories. Table 2 shows the numerical values of water parameters in accredited laboratories of public institutions in Turkey.

**Table 2. Examination of the accreditation status of accredited public institution laboratories in terms of water parameters**

Public Institution	Number of accredited quality parameters
TUBITAK	36
ASAT	35
Denizli Metropolitan Municipality	32
Antalya Metropolitan Municipality	28
Kayseri Metropolitan Municipality	27
Ministry of Environment and Urbanization	26
IZSU	25
ISTAC	21
MUSKI	7
Istanbul Metropolitan Municipality	4
MUSKI Bodrum	4

As mentioned before, there are 82 institutions (71 private and 11 public) accredited in terms of environmental parameters. All 11 institutions are accredited in all of water quality parameters while all 71 private institutions are not accredited that. Only 44 (62%) of private institutions with accredited laboratories are accredited in terms of water quality parameters. Hence, it can be said to be successful in accreditation of water quality parameters for some private institutions, while some ones have become accredited only on a few water quality parameters. Table 3 presents relationship between the most accredited water parameters and institutions.

**Table 3. Relationship between water parameters and institutions in terms of accreditation status**

	Accredited Institutions			Total
	Private	Public	University	
pH	44	11	10	65
COD	39	10	7	56
SS	40	10	6	56
Conductivity	37	8	8	53
Oil-Grease	37	8	4	49
BOD	35	7	5	47
Temperature	38	2	2	42

The most accredited water parameter is pH, with total of 65, where 44 of them are private, 11 are public and 10 are university laboratories. COD and SS are placed in the second order with total of 56. Here, 39 private, 10 public and 7 university laboratories are accredited in terms of COD and 40 private, 10 public and 6 university laboratories are accredited in terms of SS. Conductivity is the next remarkable parameter with total of 53 institutions (37 private, 8 public and 8 university laboratories) (21).

## DISCUSSION

The introduction of QMS and the accreditation of laboratories according to ISO/IEC 17025 standard are challenging tasks, primarily for those laboratories placed in teaching and research institutions. Some of the difficulties and limitations encountered are the provision of testing services is not a priority; the temporary staff has a high turnover; the laboratories are shared with the research and teaching activities; the staff's functions and responsibilities are varied and diffuse; and the staff's performance is commonly measured based on their teaching activities and publications. The main advantages of accreditation are increased customer satisfaction; increased reliability of results and staff's qualification; decreased damage to or malfunction problems of equipment; increased number of tests and bills; and receipt of government funds (22).

Malkoc and Neuteboom (2007) found that about 67 percent of public and private institution laboratories were not accredited. They asserted that there was uncertainty of perceptions about the meaning, purpose, and principles of quality assurance and accreditation among European forensic science laboratories (23). Raposo et al. (2009) performed proficiency testing of chemical oxygen demand measurements and found low laboratory performance because of heterogeneity of the samples, measurement errors, and the differences in the analysis methods (5;24).

Cortez (1999) investigated accredited and non-accredited laboratories and found accredited laboratories had more satisfactory and less suspicious and unsatisfactory laboratory performances than non-accredited laboratories. According to Cortez, accredited laboratories were more successful than non-accredited laboratories (3; 5).

Baycar (2014) conducted a study on evaluating the fulfillment of applications and evaluating the implementation of the necessary responsibilities, meeting the "General Conditions for the Qualification of Testing and Calibration Laboratories" according to ISO / IEC 17025 standard of Food Microbiology and Molecular Biology Laboratories of a company. According to this study, ISO / IEC 17025 standard and accreditation process will allow formation of up-to-date and reliable data and integrate with national and international institutions (25). Zapata-Garcio et al. (2007) conducted studies on the application of the ISO 17025 standard for the accreditation of a university measurement laboratory. They studied on Environmental Radiology Laboratory, a measurement laboratory established by the research group, to measure low-level radioactivity in the University of Barcelona. This study describes necessary properties for the realization of the quality system, which is based on the ISO 17025 standard in a small measurement laboratory

in the university (26). Sadıkoğlu and Temur (2012) investigated how a laboratory's compliance with ISO 17025 accreditation affected the performance of the laboratory. In this work, the importance of the ISO 17025 was mentioned (5). Beckett and Slay (2011) have described laboratory accreditation as providing quality assurance to laboratories for producing consistent results because it is a quality system that has been documented (27). Branter et al. (2011) explained that there is a need for a number of components to support ISO 17025 evaluation, including calibration of equipment, quality measurements for document control, as well as personnel competence and procedural qualifications (28).

The measurement of water quality parameters must be done in accredited laboratories to determine how water quality is affected by natural and human intervention, to determine the effectiveness of measures taken to protect and control water quality.

## CONCLUSIONS

Monitoring of pollutant concentrations causing water pollution, and measurement of water parameters used for pollution control must be done in the accredited laboratories. In this study, the accredited university, public institution and private sector laboratories in Turkey were examined in terms of water quality parameters. As a result, despite the fact that there are 190 universities in 2015-2016 academic year in Turkey, the laboratories of only two of these universities are more successful in accreditation of water quality parameters. These universities are Dokuz Eylül University and Muğla Sıtkı Kocman University respectively. In Turkey, there are 11 public institutions and 71 private institutions whose laboratories are accredited in terms of water parameters. In these institutions, the most accredited water quality parameters can be listed as pH, COD, SS, conductivity, oil-grease, BOD and temperature, respectively.

It is necessary to increase the number of accredited laboratories especially in universities in Turkey. An accredited laboratory allows for the elimination or reduction of test strips and assessments, ensures that laboratory standards and status are up-to-date, and that test results from the accredited laboratory are accepted by the national and international markets. In addition to all these benefits, the benefits of an accredited laboratory include improving service quality, reducing costs, and proving its reliability. Because of these benefits, accredited laboratories should be preferred in areas such as food and environment that directly affect public health.

## Competing Interests

All authors hereby have declared that no competing interests exist.

## Authors Participations

PA participated in the study design, writing the protocol, data collection, managing the analyses of the study, and writing all versions of the manuscript. OMAT participated in the study design, managing the analyses of the study. All authors read and approved the final manuscript.

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