Strengthening Quality Infrastructure for Monitoring of the River Ganga in India

Franziska Wende, Anil Saxena, Pallavi Bishnoi
Physikalisch-Technische Bundesanstalt (PTB), Germany
franziska.wende@ptb.de

D. P. Mathuria
National Mission for Clean Ganga, India

KEYWORDS
Ganga, Water Pollution, River Monitoring, Quality Infrastructure, Laboratories

ABSTRACT:

The project “Strengthening Quality Infrastructure for Water Monitoring of the Ganges River” was launched in 2018 as a part of the bilateral cooperation between the Government of India and the Federal Republic of Germany. It was commissioned by the Federal Ministry for Economic Cooperation and Development (Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung, BMZ) in the frame project of the Development Programme ‘Sustainable Urban Development (SUD) in India’. The project is implemented by the National Metrology Institute of Germany (Physikalisch-Technische Bundesanstalt, PTB) in cooperation with the National Mission for Clean Ganga (NMCG).

The project area is the Ganges River basin. After the launch of the Indian government’s Namami Gange flagship program in 2014 and the rejuvenation efforts undertaken through methodical interventions supported by the availability of surplus funds from various development agencies, the surface water quality of the river has been enhanced. Although, the river remains heavily polluted due to weakly monitored anthropogenic activities, presenting a great threat to people and the environment as well as ecosystems and biodiversity in its catchment area. The lack of reliable (quality assured) water monitoring data has been recognized as one of the decisive bottlenecks for the development of specific, appropriate, and well targeted pollution-mitigation measures as well as policy instruments for the river basin. The project has been conceived to address this issue by strengthening the capacities of relevant actors to produce credible and standardized water quality monitoring data.

This paper will especially discuss the current situation in six selected Water Monitoring laboratories in Uttar Pradesh at Kanpur, Prayagraj and Varanasi, and Dehradun, Roorkee and Kashipur in Uttarakhand, highlighting the significant developments during the ongoing project phase and the expert recommendations for steering the future efforts within the project purview.

1 BACKGROUND

Growing population and increasing industrialization began to take their toll on the environment, and especially rivers in Europe during the 19th century. At the same time, science and research made great advances, allowing the identification of harmful pollutants and pathogens. These times mark the beginning of chemical water analysis (Bülow, 2012). During the first half of the 20th century the number of available analytical methods and laboratories that measured surface water quality steadily increased. The results of different laboratories were not comparable, however, as there was a lack of standardization and quality control (Bülow, 2012). While German industries increasingly demanded standardized products and tools, and subsequently founded the German Standardization Committee of German Industry in 1917 (DIN, 2022), standards for testing laboratories were only established in the 70ies (Miguel, 2021). Just a few years earlier, several events of mass fish kill along the Rhine River had to serve as wake-up calls and led to increased national as well as international coordination (IKSR, 2022), even though previous calls from civil and environmental organizations had remained unheard. Just as in the early stages of water monitoring during the German Empire, water monitoring in modern Germany was and is mandate of each federal state, though the principles are laid out in federal law since 1957 (Bundesgesetzblatt, 1957) and European Law since 2000. The Water Framework Directive marks the supranational culmination of increased efforts to observe and improve water quality all over

Europe. Not only did it set ambitious goals for the improvement of structural, biological, and chemical water quality, but it also defined the approaches that should be used by the European Union member states in their monitoring efforts. Thus, applying the methods and quality management systems laid down in the relevant standards for testing laboratories is mandatory for all water monitoring under the Water Framework Directive (EU, 2000). In Germany, the biological and chemical quality of many water bodies has significantly improved since the 1960s in Western Germany and the 1990s in the former German Democratic Republic (Leszczynski, 2017) respectively. Strict regulations, their enforcement and adequate wastewater treatment have led to rivers that are fit for bathing again.
Despite all the progress being made, there are remaining and new challenges for ambient water quality in Germany. Agricultural pollution in the form of high concentration of nitrate is still widespread. Emerging pollutants such as microplastics, hormones and medical residue are a rising concern. So, the search for adequate analysis and effective regulation continues.

1.1. Situation in the intervention area

The river Ganga is a perennial river that originates from the Himalayas and flows through many states before its confluence with Bay of Bengal. The Ganga basin accounts for a little more than one-fourth (26.3%) of India's total geographical area and is the biggest river basin in the country. As India's holiest river, the Ganges has a high cultural and spiritual significance. Its catchment area is home to over 650 million people, more than 40 % of India's population and hundreds of aquatic species and provides water for many millions of farms, factories, and households. The main river stream originates in the northern-most part of Uttarakhand, flows through Uttar Pradesh, Bihar, and West Bengal, and finally drains into the Bay of Bengal. The river is heavily polluted, mainly due to the discharge of inadequately treated municipal and industrial wastewater and the disposal of solid waste. Apart from this, the runoff from agriculture fields causes pesticide pollution. This represents a great threat to people and the environment as well as ecosystems and biodiversity (cGanga, 2017). Vulnerable population groups such as women, people with disabilities and members of marginalized groups suffer particularly from environmental pollution and poor water quality, which affects food supply and health care. This threatens the human right to water and sanitation, as well as to an adequate standard of living for these groups (Dwivedi, 2018). The respective State Pollution Control Boards are responsible for monitoring river Ganga and providing quality analytical data.

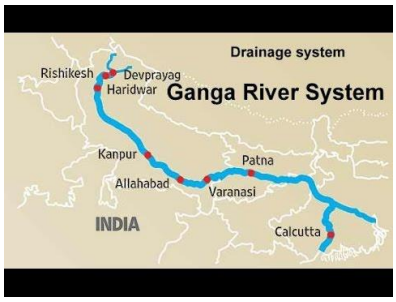

Figure – 1: River Ganga Course

Government of India has taken a number of initiatives through various agencies for effective monitoring and analysis of water quality. Under the Namami Gange program, 97 manual water quality monitoring and 36 real-time water quality monitoring stations have been established/installed on Ganga River in various states. The monitoring of the manual water stations is carried out by the State Pollution Control Boards (SPCB), while the Central Pollution Control Board (CPCB) is responsible for real-time monitoring stations.

1.2 Situation in the sector

For rejuvenating the river Ganges, the Indian government initiated the flagship programme "Namami Gange" in June 2014 with a volume of about 2.4 billion EUR for a duration of 10 years, managed and implemented by the National Mission for Clean Ganga (NMCG). Furthermore, international development partners, as the German Development Bank (Kreditanstalt für Wiederaufbau (KfW)) and World Bank have allocated funds for infrastructure projects (mainly for municipal sewerage and industrial effluent management systems) in the Ganga basin. For the development of specific, appropriate, and well targeted measures for fighting pollution and sustaining the rejuvenation of the river, reliable (quality assured) water monitoring data are needed to map concrete pollution sources and determine the respective quality and quantity of pollutants. However, today the quality of the analytic data required for the assessment and the monitoring of the water quality of the river Ganga is insufficient. The main reasons are a) deficient coordination of the assessment and analysis of data by the environmental authorities on both state

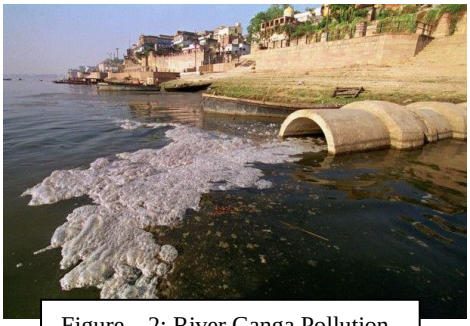
Figure – 2: River Ganga Pollution

and central level, b) the lack of a water monitoring strategy and c) inadequate equipment and lack of trained personnel in the central and regional laboratories responsible for monitoring water quality in the Ganga states. This significant gap in the availability of reliable water quality data also poses a bottleneck for scientific analysis and policymaking.

In order to strengthen water quality monitoring at the state level, the Indian Government and the Federal Republic of Germany initiated a technical collaboration project in 2018 – 19. The basic objective of the collaboration is to strengthen the selected laboratories of State Pollution Control Boards of Uttarakhand and Uttar Pradesh to strengthen their capabilities in quality monitoring and analysis of Ganga River water by identifying gaps and providing training. NMCG and PTB are the Indian implementing partners from Indian and German side respectively.

1.3 Main Project Achievements

In the beginning, the project focused on the small state of Uttarakhand (about 10 million inhabitants) at the source of the river. Soon, this approach was widened to the much bigger state of Uttar Pradesh (about 200 million inhabitants) in agreement with both the partners and BMZ. Most of the municipal and industries pollution originates in Uttar Pradesh. So, expert visits were conducted to assess laboratory capabilities of the State Pollution Control Board offices in both states. Based on the findings and the identified gaps, trainings and capacity-building activities were undertaken by PTB experts in Uttarakhand and Uttar Pradesh. Furthermore, a comprehensive summary of the assessments with a set of recommendations was handed over to NMCG and CPCB for further action. In the meantime, eight regional laboratories in Uttar Pradesh have now been accredited in accordance the standard ISO/IEC 17025:2017 during project implementation. During its activities, the project brought together expertise from India and Europe, and linked the water monitoring bodies with other relevant institutions.

2 CURRENT STATUS OF WATER QUALITY MONITORING LABORATORIES

Sampling and monitoring protocols and guidelines are very important to enable comparable monitoring results as a basis for decision making. CPCB has developed guidelines for design of monitoring stations and quality monitoring and analysis. However, these guidelines are not being followed fully. Before the start of the project none of the regional laboratories were accredited from NABL. Under the Namami Gange program, the laboratory staff were appointed for regular monitoring and analysis at all the SPCB laboratories. Also, a number of instruments have been provided to strengthen the laboratories.

NMCG selected six laboratories – three each in Uttarakhand Pollution Control Board (UKPCB) and Uttar Pradesh Pollution Control Board (UPPCB) viz; Dehradun, Roorkee and Kashipur in Uttarakhand and Varanasi, Prayagraj and Kanpur in Uttar Pradesh to implement the project. Initially, a workshop was organized by PTB to create awareness about importance of water quality monitoring and analysis along with basic concepts in laboratory analysis. Subsequently, laboratory visits to the identified laboratories were undertaken by German and Indian experts to understand their working and identify their needs.

In order to identify the gaps in the existing laboratories w.r.t. monitoring and analysis, the German and Indian experts visited laboratories at different intervals and provided guidance and training to the laboratory staff. A specialized training on microbiological analysis has been provided to select laboratories.

2.1. Uttar Pradesh

Two visits to each regional laboratory was undertaken by the PTB experts during 2019 - 2022 period. The laboratories are situated either in residential or commercial areas of respective cities. At most of the laboratories, the basic infrastructure including space and instruments were not found to be adequate for quality monitoring and analysis. The laboratory staff also have not been observed to be adequately trained. The gaps identified and recommendations made were communicated to the NMCG and respective laboratories. Initially, the laboratories were not accredited by National Accreditation Board for Testing and Calibration Laboratories (NABL) however, subsequently, they have obtained NABL accreditation. It has been observed that only one sample has been collected for analysis instead of

duplicate. The Central laboratory has also provided Standard Operating Procedures (SOPs). The laboratory staff has not been provided training on ISO 17,025.

2.2 Uttarakhand

Except Central laboratory at Dehradun, the laboratories at Roorkee and Kashipur are in the rented space. The central laboratory is well equipped with all the basic and sophisticated instruments while the regional laboratories at Roorkee and Kashipur lack basic instruments particularly for field monitoring. Roorkee laboratory were provided with field monitoring kits for Dissolved Oxygen (DO), pH at the time Kumbh mela however, DO meter is not working at the moment. NMCG has supplied basic instruments to all the laboratories under Namami Gange program. At the time of visit, instruments are yet to be installed at Kashipur laboratory. None of the regional laboratories at Uttarakhand have sophisticated Atomic Absorption Spectrophotometer (AAS) and Gas Chromatography (GC). The samples are being sent to the Central laboratory for analysis. None of the laboratories have obtained NABL accreditation. It is under preparation for Central laboratory.

There is a need for capacity building of the laboratory staff in river water monitoring & analysis and basic fundamentals of analysis such as Quality Assurance/ Quality Control (QA/QC) and Measurement of Uncertainty (MoU). The gaps have been identified and recommendations have been made to NMCG and respective laboratories.

3 ROLE OF NMCG

NMCG, under Namami Gange programme, launched a scheme, "Strengthening of laboratories of Uttarakhand Pollution Control Board, Uttar Pradesh Pollution Control Board, Bihar State Pollution Control Board (BSPCB), Jharkhand State Pollution Control Board (JSPCB) and West Bengal Pollution Control Board (WBPCB)" at a cost of Rs. 859.5 Million (Rs. 85.95 Crores) in 2018 to address the resource constraints and technical facilities for capacity building for environmental monitoring in the Ganga basin with main focus on the rejuvenation of River Ganga and its tributaries.

Out of the projected human resource strength of 234 staff, at present, total 209 technical and non-technical staff were recruited under Namami Gange programme and are working in various central and regional office level laboratories.

Development of UKPCB Central laboratory at Dehradun, Regional Office laboratories at Roorkee and Kashipur; UPPCB Central laboratory at Ghaziabad, Regional Office laboratory at Bijnor, Raibareilly, Kanpur, Prayagraj, Varanasi and Bulandshahar is completed.

Especially in case of Uttar Pradesh, the programme "Developing Control Rooms for Monitoring Polluted River Stretches in State of Uttar Pradesh" sanctioned under project, "Strengthening of laboratories in 2020 is in progress in all 09 Regional Office laboratories viz. Ghaziabad, Agra, Moradabad, Meerut, Ayodhya, Varanasi, Jhansi, Gorakhpur & Lucknow. Under this scheme total 21 staff is recruited at 07 Control Rooms (Ghaziabad, Agra, Moradabad, Meerut, Ayodhya, Jhansi, Gorakhpur). NABL Accreditation of 07 Regional Office laboratories at Ghaziabad, Bijnor, Kanpur, Bulandsahar, Prayagraj, Varanasi and Raebareily is completed.

Under this scheme, the respective SPCB laboratories (18 laboratories including Central and Regional Office level ones) are envisaged to be equipped with 58 types and total Qty. of 853 Nos. of advanced and general scientific instrument / equipment. Supply, installation, demonstration and commissioning of 06 (Qty. 65 Nos.) out of the twelve types (Qty. 115 Nos.) of advanced scientific instruments / equipment being procured through International Competitive Bidding (ICB) is in final stage of the completion at the respective delivery locations of UKPCB, UPPCB, BSPCB, JSPCB and WBPCB. The instruments include Atomic Absorption Spectrometer with Graphite furnace and Hydride Generation System, Microwave Digester, UV-VIS Spectrophotometer (double beam), Total Organic Carbon Analyser, RO based Water Purification System and AOX/ TOX Analyser. Similarly, installation of 41 type (Qty. 227 Nos.) of general scientific instruments / equipment at central and regional office level laboratories of SPCBs is completed.

4 ASSESSMENT AND UPGRADATION OF QUALITY INFRASTRUCTURE

The aim of the “Strengthening Quality Infrastructure for Water Monitoring of the Ganges River” Project is to improve the quality of data used to monitor the Ganges River via improved sampling and analysis of water samples in line with recognized quality-assurance measures and by improved coordination between all competent bodies involved.
The PTB Project does this by applying a methodical approach based on technical advisory and training measures. In this context, PTB experts, together with NMCG and UPPCB, UKPCB have undertaken assessments of regional Water Quality Monitoring laboratories in Uttar Pradesh and Uttarakhand. The assessment of laboratories has augmented the Team’s understanding of the situation in environmental water laboratories, their needs and to better adjust PTB activities to build capacities and to strengthen the laboratories and to improve/ensure the quality of data.

These laboratory assessments have been undertaken at the beginning of the project phase (2019/2020) and after successful implementation of planned project activities (2022). A comparative analysis of the situation of three labs (Kanpur, Prayagraj and Varanasi) has been conducted to evaluate the impact of the project so far and identify the crucial gaps that need focus during the planning of future project activities.

4.1 Comparative Analysis

The comparative analysis is based on the assessment of laboratories on five broad criteria that impact the quality of data and results generated from these labs for monitoring of River Ganga, namely:

1. Infrastructure and Premises (Building/ Area, Designated rooms, Temperature control, Power Backup)
2. Equipment (Sampling, Storage, Testing Instruments, Safety, IT)
3. Human Resources (Number, Qualification, Sustainability, Capacity)
4. Technical Competence (Sampling Procedure, Sample handling, Parameters, Testing SOPs, Results Reporting, Training)
5. Quality Assurance/ Quality Control (Accreditation, Proficiency Tests, Inter/ Intra Laboratory Comparison, Calibration)

Table 1 below summarizes the comparative analysis for all 3 laboratories at Kanpur, Prayagraj and Varanasi. The status of these laboratories based on the above 5 criteria and sub-criteria is reported in terms of red, yellow and green colours representing No/ Inadequate, Yes with Gaps/ Work in Progress (WIP) and Yes/ Adequate respectively. This data has been collected during the laboratory assessments as well as extracted from PTB expert reports which give a more detailed outlook to the situation in the laboratories.

It is evident from Table 1 that both PTB and NMCG projects have successfully transformed the condition of these laboratories and continue to do so by conceptualising customised Training and Capacity building programs for the laboratories aligning with the procurement of new sophisticated instruments.

Table 1: Comparative analysis of the status of laboratories during the project phase

SN	Criteria/ Laboratory	KANPUR		PRAYAGRAJ		VARANASI	
		2020	2022	2020	2022	2019	2022
1	**INFRASTRUCTURE & PREMISES**						
a	Building/Area	Old/cramped	More space	Cramped	More space	Old/cramped	More space
b	Designated Rooms	N	Y (Gaps)	N	Y (Gaps)	N	Y (Gaps)
c	Ambient Temp Control	N	Y (Gaps)	N	Y (Gaps)	N	Y (Gaps)
d	Power Backup	N	Y (Gaps)	N	Y (Gaps)	N	Y (Gaps)
e	Control Room	N	Y	N	Y	N	Y
2	**EQUIPMENT**						
a	Sampling	Inadequate	Y (Gaps)	Inadequate	Y (Gaps)	Inadequate	Y (Gaps)
b	Storage	Inadequate	Adequate	Inadequate	Adequate	Inadequate	Adequate
c	Testing Instruments	Inadequate	WIP*	Inadequate	WIP*	Inadequate	WIP*
d	Safety	Inadequate	Y (Gaps)	Inadequate	Y (Gaps)	Inadequate	Y (Gaps)
e	IT	Inadequate	Adequate	Inadequate	Adequate	Inadequate	Adequate
3	**HUMAN RESOURCES**						
a	Number	18	28	16	19	14	29
b	Qualification	Unclear	Govt. Std.	Unclear	Govt. Std.	Unclear	Govt. Std.
c	Sustainability	N	Contracts	N	Contracts	N	Contracts
d	Capacity & Training	Inadequate	WIP	Inadequate	WIP	Inadequate	WIP
4	**TECHNICAL COMPETENCE**						
a	Sampling Procedure	Inadequate	Y (Gaps)	Inadequate	Y (Gaps)	Inadequate	Y (Gaps)
b	Sample handling	Inadequate	Y (Gaps)	Inadequate	Y (Gaps)	Inadequate	Adequate
c	Parameters	18 (Gaps)	23 (WIP)	17 (Gaps)	38	8 (Gaps)	25 (WIP)
d	Testing SOPs	N	Y (Gaps)	N	Y (Gaps)	N	Y
e	Results Reporting	Y (Gaps)	Adequate	Y (Gaps)	Adequate	Y (Gaps)	Adequate
5	**QUALITY ASSURANCE/ QUALITY CONTROL**						
a	Accreditation	N	Y (13)	N	Y (13)	N	Y (13)
b	Proficiency Tests	N	Y	N	Y	N	Y
c	Inter/ Intra Laboratory Comparison	Y (Gaps)	Y	Y (Gaps)	Y	Y (Gaps)	Y
d	Calibration	N	Y (Gaps)	N	Y (Gaps)	N	Y (Gaps)
e	Certified Reference Material	N	Y (Gaps)	N	Y (Gaps)	N	Y (Gaps)

* *Many new instruments have been procured and more sophisticated instruments are continuously being procured by NMCG under the "Strengthening of Laboratories" Project.*

5 IDENTIFIED GAPS

The basic need for quality monitoring and analysis is well qualified and trained staff along with basic infrastructure. The Central laboratories in both the states have been found to be well equipped with all the basic infrastructure and equipment. However, in most of the visited regional laboratories at Uttarakhand and Uttar Pradesh, the basic infrastructure has been found to be lacking both for water quality monitoring and analysis. Though the laboratories at Uttar Pradesh are now performing Proficiency Test and Inter Laboratory Comparison tests however, such practice is not being followed at Uttarakhand. It has been observed that the guidelines prepared by CPCB for Water Quality Monitoring have not been followed fully.

Based on the laboratory assessments and the comparative analysis reported above, few critical gaps have been identified as common at all three labs:

- The building premises do not have adequate space to accommodate newly procured instruments. This constraint needs to be addressed foremost before any further procurements.
- The Ambient conditions are not being maintained for ensuring quality results. Proper Air curtains for microbiological testing, Air conditioning, stable power backup and designated areas need to be in place at all laboratories. This also needs to be ensured for adequate functioning of newly procured sophisticated instruments.
- While a substantial upgrade has been noticed in the sampling, testing and analytical procedures as a result of trainings conducted by PTB as well as NABL accreditations, many gaps have still been observed in following the recommended SOPs, Calibration standards, Certified Reference Materials (CRMs) and Safety Protocols. All these factors impact the quality of data that is being generated at these laboratories.
- Many new staff members have been recruited under the NMCG project, but the contractual issues of this staff lead to unsustainability in retainment of qualified personnel.
- Customised Training Programs need to be continuously designed for the laboratory staff based on their requirements and expert recommendations.

6 CONCLUSION

Based on the visit and discussions held with the laboratory staff and observations made by PTB experts, the following suggestions / recommendations have been made to improve the performance of the laboratory in providing quality analytical data.

General Conditions:

In order to perform quality analysis, it is essential to have proper environment in the laboratory with proper temperature. It is suggested to provide adequate air conditioning system to maintain the required temperature, particularly in the room having sophisticated instruments such as AAS & GC. The safety of the instruments is of importance, and they need to be supplied with UPS in case of power failure. All the laboratory buildings have common DG set for the entire building which may not be good enough for the instruments. Therefore, the laboratory instruments should have dedicated uninterrupted power supply system based on the electricity load of the instruments. The lighting system is important while analysing the parameters. It was observed that lighting at Kanpur laboratory was not sufficient hence, it needs to be improved. The laboratories lack in safety gadgets except apron. There is no emergency shower in the laboratory at Varanasi however, it is non-functional at Kanpur. There is a need to provide safety gadgets such as safety goggles immediately. There is a need to provide field monitoring instruments such as pH & DO meters along with auto sampler. The regular check on the instrument and checking analytical results and/or calibrating with the help of CRMs should be performed along with maintaining proper calibration records.

The monitoring of river is being carried out in the river course. The monitoring staff do not have safety jackets hence, safety jackets should be provided to the field monitoring staff.

Microbiology Lab:

For better and quality data, the provision for air curtain and proper air conditioning system in the microbiology lab should be provided. IIT Kanpur has developed Water Testing Kit for E. coli in drinking water. The Central laboratories can procure the same for quick analysis.

Capacity Building:

The laboratory staff needs training in general good analytical practices, MoU and data management practices along with internal QA/QC programs. The laboratories in Uttar Pradesh have obtained NABL accreditation and at Uttarakhand laboratories are in the process of obtaining such certification. The laboratory staff should be provided training on ISO 17,025 on Laboratory Management System (LMS) covering method validation, analytical procedures including SOPs. There is a need to create awareness about importance of CRMs in quality analytical data and maintenance of calibration records.

Field Monitoring and Sampling:

Only one sample is being collected for analysis. It is recommended to collect duplicate samples at least for cross checking the results. The sample collection system is quite rudimentary. It is suggested to procure Ratner Water Sampler for collection of samples from river.

Analysis:

The laboratories are continuing only single analysis. The samples should be analysed in triplicate and the average should be reported. The laboratory staff should use the stickers for the reagent bottles and sample containers with clear indication about dates of preparation and expiry.

AKCNOWLEDGEMENT

This paper and the work behind it would not have been possible without the exceptional support of Shri G Asok Kumar, Director General, NMCG and the ever-dedicated NMCG team including Dr. Ishaq Ahmad and Dr. Hema Patel. As the Project Implementing Partner, NMCG Team's enthusiasm, knowledge and exacting attention to detail have been an inspiration. We are also extremely grateful for the kind support and cooperation from CPCB, SMCG-UP & UK, UPPCB and UKPCB along with all the Regional labs under the project and their kind staff. We are also grateful for the warm collaboration with the teams of GIZ and KfW in India. The Technical guidance and insights offered by Dr. Swarupa Tripathy at National Physical Laboratory (NPL) have also been critical towards the development of this project. Finally, it is with true pleasure that we acknowledge the contributions of PTB team members and experts Uwe Miesner, Lea Weber, Dr. Swati, Dr. Gerhard Rappold, Christine Froese, Katharina Telfser, Peter Lepom, Ulrich Diekmann, Patrick Dolle and everyone who has been a part of this project.

REFERENCES

Bülow, W., 2012. 100 Jahre Umweltanalytik in Niedersachsen – Rück- und Ausblick. Niedersächsischer Landesbetrieb für Wasserwirtschaft, Küsten- und Naturschutz, Hildesheim.

Bundesgesetzblatt, 1957. [Online]
Available at:
https://www.bgbl.de/xaver/bgbl/start.xav?startbk=Bundesanzeiger_BGBl&jumpTo=bgbl157s1110.pdf#__bgbl__%2F%2F*%5B%40attr_id%3D%27bgbl157s1110.pdf%27%5D__1666012166835

DIN, D. G. v., 2022. Deutsches Institut für Normung e. V. [Online]
Available at: https://www.din.de/de/din-und-seine- partner/din-e-v/chronik

Dwivedi, S., 2018. Ganga water pollution: A potential health threat to inhabitants of Ganga basin. Environment International, pp. 327-338.

EU, 2000. Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy. [Online]
Available at: https://eur-lex.europa.eu/legal- content/EN/TXT/?uri=CELEX:32000L0060

IKSR, 2022. Aufbau einer Zusammenarbeit. [Online]
Available at: https://www.iksr.org/de/iksr/ueber-uns/geschichte/aufbau-der- zusammenarbeit

Leszczynski, U. v., 2017. Von der Giftbrühe zum Badefluss, Wirtschaftswoche. [Online]

Available at: https://www.wiwo.de/technologie/green/das-kleine-wunder-der-elbe-von-der-giftbruehe-zum-badefluss/19971778-all.html

Miguel, A. &. M. R. &. O. A. F., 2021. ISO/IEC 17025: history and introduction of concepts. Química Nova, Volume 44.