

# Strengthening Quality Infrastructure for Water Monitoring of the Ganga River

Proceedings of the kick-off workshop for the project



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On behalf of



On behalf of the German federal government, the Physikalisch-Technische Bundesanstalt (PTB) promotes the improvement of framework conditions for economic activity, thereby supporting the establishment of metrology.

# Acknowledgements

This report describes the kick-off workshop of the *Strengthening Quality Infrastructure for Monitoring Water Quality of the Ganga River* project which was conducted by the Physikalisch-Technische Bundesanstalt (PTB) with the National Mission for Clean Ganga (NMCG) on 19 February 2019 in Delhi, India.

I wish to thank the teams from NMCG and PTB for their joint effort in organizing the event. Special thanks go to Shri D.P. Mathuria, Executive Director (Technical) of NMCG and Shri Rajiv Kishore, Executive Director (Administration) of NMCG.

Moreover, I would like to express my gratitude to the moderator, resource persons and experts as well as to the rapporteurs and participants from the relevant institutions that monitor the water quality of River Ganga for their valued contributions.

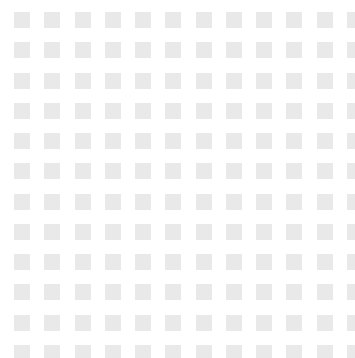
I hereby present this summary of the proceedings to all the stakeholders and readers alike.



Shri R.R. Mishra, DG NMCG, giving the welcome address

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Shri Rajiv Ranjan Mishra  
 Director General of NMCG  
 National Mission for Clean Ganga  
 Ministry of Water Resources, River Development  
 and Ganga Rejuvenation





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# 1. Concept of the Workshop

National Mission for Clean Ganga (NMCG), together with Physikalisch-Technische Bundesanstalt (PTB), organised a one-day workshop to mark the kick-off of their collaboration within the PTB Ganga project *Strengthening Quality Infrastructure for Water Monitoring of the Ganga River*.

The objective of the project is to improve the quality of data which are used to monitor the Ganga River through improved sampling and water sample analysis based on recognised quality-assurance measures as well as improved coordination among all competent bodies.

The workshop brought together the relevant stakeholders for water quality monitoring of the Ganga River including (among others) NMCG, the Central Pollution Control Board (CPCB), four of the five State Pollution Control Boards (SPCBs) of the Ganga River basin, the Central Water Commission (CWC), the Center for Ganga River Basin Management and Studies (cGanga), relevant research institutes, non-governmental organisations (NGOs) and international development cooperation partners.

The aims of the workshop were the following:

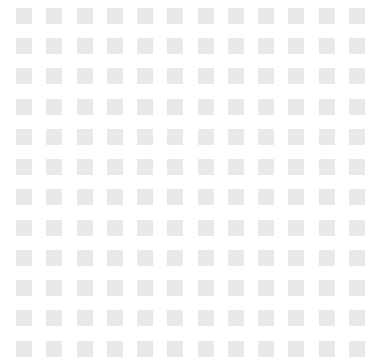
- To present the scope of the planned project and possible activities to the main stakeholders
- To receive input from key stakeholders
- To strengthen the commitment of the key stakeholders.

The workshop started with an inaugural session during which representatives of NMCG and the German Embassy extended a warm welcome to the workshop participants.

During the first technical session, Mr. Patrick Dolle, project coordinator of the PTB project, presented PTB, the National Metrology Institute of Germany, and outlined the project. PTB's expert Dr. Peter Lepom, who introduced water monitoring and assessment under the European Water Framework Directive, spoke next. The last two speakers, Mr. Rajendra Mohan Bhardwaj and Ms. Priyanka Chaudhary, presented the current status of water quality monitoring under NMCG and an overview of the monitoring activities of CPCB, respectively.

The second technical session commenced with a presentation of the envisioned activities of the PTB project, followed by presentations of the partner institutions which gave insight into their involvement in water quality monitoring and highlighted potential connections and entry points for concrete project activities.

In the concluding session, PTB, NMCG and cGanga presented a summary of the workshop, highlighting the most important aspects which were discussed and concluding the event with final remarks.



Participants of the project kick-off workshop at NMCG

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## 2. Summary of the Proceedings

### 2.1. Inaugural Session

The inaugural session was initiated by Mr. Rajiv Kishore, Executive Director of Administration of NMCG. He highlighted the great importance of the quality of monitoring data for NMCG and welcomed the PTB project. The discussion on what needs to be measured and the improvement of data accuracy was underlined as highly valuable for water quality monitoring in the Ganga River basin.

In his welcome address, Mr. Rajiv Ranjan Mishra, Director General of NMCG, expressed his appreciation of PTB's focus on the intervention area as the project complements the efforts of the many ongoing projects for improving water quality, rejuvenation and public outreach in and around the Ganga River. The new project will address the challenges of data quality and focus on sampling and analysis procedures. He invited the project to gener-

ate outcomes which are of value for all the states of the Ganga River basin and to facilitate the dissemination of knowledge in collaboration with cGanga, the knowledge hub of the national programme. Besides Uttarakhand, Uttar Pradesh should also be in the geographical focus in the initial phase of the PTB project considering the great challenges that the state faces in terms of water quality. Given the involvement of many actors in the efforts to rejuvenate the Ganga River, coordination and synergies with other activities are crucial for the success of the new project. Mr. Rajiv Ranjan Mishra thus encouraged the workshop participants to collaborate closely and ended by saying that many people are optimistic that all the joint efforts and partnerships like this will make a change.

Mr. Wolfgang Köster, Deputy Head of the Department of Economic Cooperation of the German Embassy, introduced PTB as one of the implementing agencies of Indo-German development cooperation. He pointed



The panel of the concluding session from left to right: Mr. Wolfgang Köster, German Embassy Delhi; Ms. Christiane Hieronymus, German Embassy Delhi; Mr. Shri R.R. Mishra, NMCG; Mr. Rajiv Kishore, NMCG; Mr. D.P. Mathuria, NMCG.

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D.P. Mathuria, ED Technical, opening the workshop

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Christiane Hieronymus, German Embassy in Delhi, opening the workshop

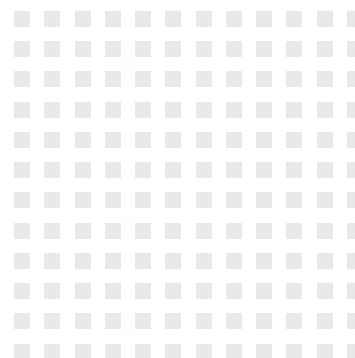
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out that India is Germany's biggest bilateral development cooperation partner and that the rejuvenation of the Ganga River is a focus of this cooperation. PTB, with its expertise in measurement and data accuracy, can contribute to this effort by concentrating its know-how on improving the quality of water monitoring data.

Ms. Christiane Hieronymus, Head of Economic Cooperation at the German Embassy, also emphasised that reliable measurement results are crucial and expressed her appreciation of PTB's joining forces with the German Society for International Cooperation (Gesellschaft für Internationale Zusammenarbeit, GIZ) and the German Development Bank (Kreditanstalt für Wiederaufbau, KfW) to support Indian efforts to rejuvenate the Ganga River.

Finally, Mr. D.P. Mathuria, Executive Director Technical of NMCG, mentioned the large number of infrastructure projects which support the rejuvenation efforts. Water quality monitoring plays a key role in validating the positive effects of these investments. It is thus of major importance that the different actors who are involved in

monitoring are considered and that the different protocols and guidelines which are used are fully understood and taken into consideration when defining of the activities of the PTB project.



## 2.2. Technical Session I

### *Presentation of PTB and the “Strengthening Quality Infrastructure for Water Quality Monitoring of the Ganga River” project*

In the first technical session, Mr. Patrick Dolle, project coordinator of PTB, presented PTB – the National Metrology Institute of Germany. It is one of the implementing agencies of German international cooperation, together with GIZ, KfW and the Federal Institute for Geosciences and Natural Resources (BGR). PTB’s focus in international cooperation lies on sharing its core competence and on supporting developing and emerging economies in the field of quality infrastructure. Quality infrastructure encompasses all the institutions that provide services for quality assurance. These institutions enable compliance with existing regulations, knowledge and application of the quality requirements of specific markets.

Since the 1980s, PTB has collaborated with Indian organisations. The last project which concerned environmental measurements was carried out from 2009 to 2016 and involved National Physical Laboratory of India (NPL), the Council of Scientific and Industrial Research, the National Environmental Engineering Research Institute (NEERI) in Nagpur, the Indian Institute of Toxicology Research

(IITR) in Lucknow, CPCB and the National Accreditation Board for Testing and Calibration Laboratories (NABL) as partners. Presently, a project on quality assurance for the Indian solar industry is being implemented with the National Institute of Solar Energy (NISE) as the main partner organisation.

The new project *Strengthening Quality Infrastructure for Water Quality Monitoring of the Ganga River* supports the provision of quality-assuring services for monitoring the water quality of the Ganga River. Therefore, the technical competence of the bodies tasked with the planning, implementation and utilization of monitoring programmes for the Ganga River shall be strengthened. Additionally, the laboratories which monitor the water quality of the Ganga River will be supported in the areas of quality management, sampling and analytical testing. Furthermore, the project aims to foster the coordination of all competent bodies to increase the cooperation among the bodies and with other involved parties.

The project will operate at the national level and at the federal state level; Uttarakhand serves as a pilot region. Depending on the topic, stakeholders of all five federal states along the main stream of the Ganga River – Uttarakhand, Uttar Pradesh, Bihar, Jharkhand and West Bengal – shall be involved. The official partner is the Ministry of Water Resources, River Development and Ganga Rejuvenation (MoWR, RD & GR).



Figure 1: Quality infrastructure – a complex network

The main implementation partner of project is NMCG as well as the SMCG. Other key partners are the regulatory bodies CPCB and the SPCBs as well as research institutes and environmental laboratories.

The project has a budget of 1,000,000 EUR and has a runtime of three years – from November 2018 to October 2021.

Mr. Patrick Dolle pointed out that the success of the new PTB project will depend on the collaboration with the involved institutions and he invited the workshop participants to consider the project in their endeavours so that a meaningful contribution can be achieved.

#### *Insights into the European approach: Water Monitoring and Assessment under the European Water Framework Directive*

Next, Dr. Peter Lepom, technical expert of PTB, summarised the principles of the European Water Framework Directive (WFD) and placed a special emphasis on monitoring requirements and assessment before providing an overview of the status of German waters in 2015.

The WFD was established 19 years ago and forms the basis for monitoring surface waters and groundwater in Europe. This legislation resulted in fundamental changes for the monitoring programmes of rivers, lakes and transitional and coastal waters. The status of waters is assessed using a range of criteria which include biological, physico-chemical, chemical and hydromorphological aspects. Water bodies were introduced by the WFD as objects of assessment and management. The term *water bodies* denotes certain sections or parts of waters which are uniform in their pressures and structures and that furthermore belong to a certain *category* (groundwater, river, lake, transitional or coastal water) and to a particular *type*.

The ecological status of surface waters should be *close to natural conditions*. The criteria for assessment are water type-specific reference conditions for the presence and abundance of flora and fauna, physicochemical conditions such as nutrients, oxygen levels, temperature and pH and hydromorphology. The ecological status of a water body is defined according to its deviation from these reference conditions and is assessed using five categories (high, good, moderate, poor and bad). Addi-

tionally, national environmental quality standards (EQS) apply to specific pollutants of regional relevance.

The WFD defines the chemical status of surface waters in terms of compliance with EQS set to European levels for 45 priority pollutants. These standards represent the levels of toxic concentrations that do not pose a threat to aquatic organisms and humans. If the EQS for one of the substances is exceeded, good chemical status of the water body cannot be achieved.

In Germany, roughly 50% of waters are still in poor or bad ecological condition; only 8% achieved a good or high category. The ecological status of lakes is generally better than that of rivers.

In terms of the chemical status of surface waters in Germany, all surface waters currently fail to achieve a good status according to the criteria of the WFD. However, for 84% of German waters, this is exclusively due to the presence of one or several of four ubiquitous, persistent, bioaccumulative and toxic substances which are outside of human control.

#### *The Indian perspective: A presentation of the status quo in water quality monitoring by NMCG and CPCB*

After the overview of the European approach to water quality monitoring, the status of water quality monitoring for the Ganga River was presented.

Mr. Rajendra Mohan Bhardwaj, NMCG consultant, gave an overview of the legal framework, including the Water (Prevention & Control of Pollution) Act of 1974, the Environment (Protection) Act of 1986 regarding sources of pollution and the Water Quality Assessment Authority Order of 2005 that is adhered to by all agencies involved in water monitoring. Several institutions are involved in water monitoring in India. These include (amongst others) the CPCB and SPCBs, the CWC and State Irrigation Departments, the Central Ground Water Board and State Ground Water Departments, the National River Conservation Directorate (NRCD) and NMCG. The different central institutions have set up networks of monitoring locations, and guidelines as well as protocols which are published by CPCB and the Water Quality Assessment Authority are in use.

The existing network of various agencies have well-designed monitoring programmes which cover the majority of issues in view of the mandate of each agency. The collected data allow the agencies to identify trends in water quality as well as polluted stretches of the river. Nevertheless, some weaknesses remain. These lie mainly in poor onsite analysis of field parameters, analysis of microbiological parameters, micro pollutants and emerging pollutants, data validation tools and quality assurance. Hereby, quality assurance is relevant not only within the laboratory – where samples are received, analysed and results interpreted – but also outside the laboratory from site selection and monitoring plans, to sample collection, handling and transport.

Mr. Rajendra Mohan Bhardwaj invited the PTB project team to review the prevailing methodologies for monitoring and analysing the data of the Ganga River as a first step. With this information in mind, concrete actions to strengthen skills and infrastructure could then be defined. He suggested amongst others that the project could provide recommendations for improving the current practices, support enhanced coordination among monitoring agencies or develop a protocol for real time monitoring and data validation.

Following the presentation by NMCG, Ms. Priyanka Chaudhary provided an overview of water monitoring that is carried out by CPCB. CPCB's monitoring network includes 94 manual stations where a total of 63 parameters are monitored and 36 real-time monitoring stations, where data on 17 physicochemical and biochemical parameters are collected. This data then goes through in-house validation at CPCB. The installation of 40 additional real-time monitoring stations has been proposed for the Ganga River and its tributaries.

CPCB has a central laboratory that is accredited in accordance with ISO/IEC 17025:2005 by NABL. On the state level, regular quality control exercises are carried out among laboratories.

Water monitoring data show that the middle and lower stretches of the Ganga River are most affected by faecal coli; especially the lower stretch shows low compliance levels with outdoor bathing criteria. The middle stretch also shows problematic levels of biochemical oxygen demand (BOD); however, an improvement could already be registered between 2017 and 2018.



Question and answer session after the presentations

## 2.3. Technical Session II

### *Possible intervention areas and concrete activities of the PTB project*

The second technical session began with a presentation of some possible project activities by Ms. Katharina Telfser, PTB Project Consultant. The suggested primary intervention areas of the PTB project will on the one hand support selected laboratories in sampling, testing, quality management and strengthening of state laboratories in

upgrading and related needs. On the other hand, the project offers support to the agencies that are responsible for water quality monitoring in terms of designing monitoring programmes and the effective use of real-time water quality monitoring systems.

The following concrete activities were recommended by PTB. Workshop participants indicated their priorities and gave feedback on stakeholders to be involved in the project activities (see Annex 3). The highest priority was attributed to the activities related to sampling and quality management in laboratories.

| Intervention areas  | Priority                        |
|---|---------------------------------|
| <b>Strengthening capabilities for sampling, handling of samples and preservation</b> <ol style="list-style-type: none"> <li>1. Review of existing sampling guidelines to identify possible weaknesses or gaps</li> <li>2. Support in the implementation of recommendations (e.g. through field-training events)</li> </ol>  | High: 12<br>Medium: 5<br>Low: 0 |
| <b>Strengthening capabilities for testing in microbiological, pesticide and heavy metal analysis</b> <ol style="list-style-type: none"> <li>1. Evaluation of relevant laboratories and recommendations by an external expert</li> <li>2. Training workshop organised at the respective laboratory</li> <li>3. Possible training in a laboratory with experience in the required analyses (e.g. in Germany)</li> </ol>   | High: 8<br>Medium: 9<br>Low: 0  |
| <b>Strengthening quality management capabilities of laboratories</b> <ol style="list-style-type: none"> <li>1. Training workshops focused specifically on internal quality control               <ul style="list-style-type: none"> <li>• Promotion of the use of control charts</li> <li>• Method validation (including measurement uncertainty)</li> </ul> </li> <li>2. Organisation of proficiency tests for relevant monitoring parameters</li> <li>3. Workshop to assist laboratories in their task of becoming accredited according to ISO/IEC 17025</li> </ol>                                 | High: 12<br>Medium: 5<br>Low: 0 |
| <b>Support for the upgrading of laboratories</b> <ol style="list-style-type: none"> <li>1. Advising on how to set up an environmental laboratory (including sampling facilities)               <ul style="list-style-type: none"> <li>• Recommendations for the selection of the appropriate equipment</li> <li>• Business planning, including cost estimations for laboratory operation</li> </ul> </li> </ol>   | High: 10<br>Medium: 4<br>Low: 3 |
| <b>Strengthening capacities in programme design monitoring</b> <ol style="list-style-type: none"> <li>1. Workshop on strategies of designing monitoring programmes               <ul style="list-style-type: none"> <li>• e.g. pressure-impact analysis, objective of the monitoring, required confidence</li> </ul> </li> <li>2. Exchange of experiences with experts from other countries on water quality criteria</li> <li>3. Advice on the establishment or optimization of a water quality monitoring programmes in a specific region</li> <li>4. Study trip abroad</li> </ol>                  | High: 5<br>Medium: 10<br>Low: 2 |
| <b>Validation study under typical conditions along the Ganga River</b> <ol style="list-style-type: none"> <li>1. Inventory of the existing systems and selection of a system for the validation study</li> <li>2. Validation study in collaboration with the operator</li> <li>3. Based on the study:               <ul style="list-style-type: none"> <li>• Development of protocols for calibration and validation of the systems</li> <li>• Recommendations for the use of a real-time water quality monitoring system (RTWQMS)</li> <li>• Specification of the limitations</li> </ul> </li> </ol> | High: 11<br>Medium: 5<br>Low: 1 |

*Presentations by the stakeholders*

Following the presentation of PTB's suggestions for activities, the key stakeholders in water quality monitoring of the Ganga River presented themselves to the project team. Some of them highlighted concrete needs for support that may be addressed in the outline of the project.

Mr. Ravi Shankar gave an introduction on the water monitoring network CWC. The institution has 121 monitoring stations and seven laboratories which analyse water samples in the Ganga River basin. Three of the laboratories are accredited in accordance with ISO/IEC 17025:2005, while the remaining four laboratories are working towards an accreditation. Support from the PTB project to strengthen laboratories is seen as important, whereby testing for metals in the water and sediment was mentioned as a priority.

Then, representatives of the Pollution Control Boards of Uttarakhand, Uttar Pradesh, Bihar and Jharkhand presented their monitoring infrastructure, key competencies, quality control measures and constraints. They expressed the need for support to strengthen their laboratories for water quality monitoring. Moreover, the SPCBs are to be involved in capacity building activities, as they can act as multipliers at the district level.

NPL was represented by Senior Scientist Ms. S. Swarupa Tripathy Ph.D. As the National Metrology Institute of India, NPL is mandated to disseminate measurement traceability to the International System (SI) of Units within India. It is thus an important partner for laboratories engaged in water quality monitoring.

Moreover, the GIZ is supporting the rejuvenation of the Ganga River. Concretely, GIZ is working on the development of *Water Quality Dashboards* for the Ganga and the Hindon River basins, in collaboration with other implementing agencies such as the 2030 Water Resources Group and within the scope of the India-EU Water Partnership. Activity of PTB, specifically in the Hindon River Basin pilot, was suggested in the areas of sampling and testing.

Next, cGanga highlighted the importance of clearly defining the reason why monitoring is necessary before deciding what needs to be monitored and how this can be done

cost effectively. This makes the process more efficient and the results more viable. Solutions should be based on evidence and selected with sustainability in mind. Moreover, it was pointed out that stakeholders at different levels should be engaged.

The People's Science Institute (PSI) is a voluntary organisation that carries out environmental quality monitoring *for the people, by the people*. PSI has been involved in water quality monitoring for 30 years. PSI supports organisations with information about water quality, thus enabling them to better understand how to protect the river and environment.

Finally, the World Wildlife Fund (WWF) informed the workshop participants that it carries out river assessments on a yearly basis in three cities before the monsoon and considers river flow, water quality, biodiversity and the community perception. With awareness campaigns and activities to save water and reduce pollution, a major impact on community perception could be achieved over the years.



## 2.4. Concluding Session

In his final remarks, Mr. Patrick Dolle pointed out that accurate monitoring of water quality is crucial to be able to show the progress that is being made by all the stakeholders. Reliable data are thus key. The kick-off workshop was an important first step, bringing together the many stakeholders involved in the rejuvenation of the Ganga River. Additionally, it allowed the PTB team to gain a very good overview of the current situation in India through presentations by the key stakeholders. The next step will be taking action based on these joint discussions. The PTB project will start work at the state level and focus on strengthening sampling and testing capacities. The success of the project depends on good collaboration with all relevant stakeholders. Mr. Patrick Dolle thanked NMCG for their strong support and the outstanding organisation of the kick-off workshop.

Mr. D.P. Mathuria presented the final remarks for NMCG. He pointed out that NMCG is strengthening laboratories in five states, supporting equipment purchases and personnel. The upgrading plan for the laboratories can

be reviewed in the outline of the PTB project. Concrete needs for support will be clarified in further meetings and relevant activities will be included in the implementation plan. He also said that the information received during the kick-off workshop shall be taken into consideration for the project planning.

Mr. Vinod Tare, Founding Head of cGanga, concluded that a lot of synergies are possible between the centre and PTB. He pointed out that the real challenge is not to learn, but to unlearn some things and relearn some others. He thus invited the stakeholders to take advantage of this new collaboration and use it to reconsider what is needed and how to best address the identified needs.



The panel of the concluding session from left to right: Mr. Vinod Tare, cGanga; Mr. Rajiv Kishore, NMCG; Mr. Patrick Dolle, PTB; Mr. D.P. Mathuria, NMCG.

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## 3. Outlook

Considering the results of the workshop, the following activities are envisaged. The implementation plan can be found below.

### 3.1. Sampling

Water samples for analysing water quality parameters are taken according to the Indian *Guidelines for Water Quality Monitoring* published by the Central Pollution Control Board (CPCB) in 2007. The document is available at the CPCB website and has, to our knowledge, not been updated or revised since its publication.

It provides guidance on sample labelling, preservation and transport, sampling devices, sample types, sample containers, sample volume and the required documentation.

An international expert will review the latest available version of this guideline to clarify whether it represents the current state of knowledge and to identify areas for improvement/optimisation. International Standards which are available such as *ISO 5667-6:2014 Water quality – Sampling – Part 6: Guidance on sampling of rivers and streams*, *ISO 5667-3:2018 Water quality – Sampling – Part 3: Preservation and handling of water samples* and *ISO 19458:2006 Water quality – Sampling for microbiological analysis* will serve as reference.

An international (or national expert) will teach training courses on international best practices for taking water samples for the purpose of environmental monitoring and on quality assurance and quality control of environmental water sampling and handling. Furthermore, he or she will attend a sampling campaign conducted by a laboratory involved in monitoring of the Ganga River. It is further planned that the expert will demonstrate how to take water samples in an appropriate manner in the field.

The observations which will be made during that campaign will be evaluated and recommendations will be given based on the outcome of the field visit and the review of the sampling guideline. For this purpose, we will

organise a workshop at which the field observations and the results of the review process will be discussed with representatives of the participating laboratories and other stakeholders. The objective of this workshop is to agree on modifications of the sampling procedure (including sample handling, preservation, transport, storage and documentation) which is currently applied for monitoring of the Ganga River, where required.

### 3.2. Microbiological analysis

Coliform bacteria have long been used as water-quality indicators as these organisms are present in the intestines of warm-blooded animals and their presence in water may indicate that recent faecal contamination has occurred. Total number of and types of faecal coliforms are key parameters for water classification and are thus regularly measured in the Ganga River basin using American Public Health Association (APHA) methods. Strengthening the capacities of the laboratories in conducting microbiological analysis of surface water samples will therefore be a focus of the PTB project.

An international expert will review the methods for the determination of total and faecal coliforms in surface water to determine whether these methods are suitable for the intended purpose. Furthermore, he or she will visit some of the laboratories to assess the laboratory facilities and the ability of the staff involved to carrying out microbiological analyses.

The training courses to be held will include lectures and exercises on:

- Sampling for microbiological analysis
- Enumeration of microorganisms by culture
- Characterization of microbiological methods
- Preparation, storage and performance testing of culture media
- Variability of test results and the uncertainty of measurement of microbiological enumeration methods
- Proficiency tests in microbiological analyses



Finally, we will organise training visits for selected laboratory personnel in expert laboratories in India or abroad. Those visits aim to deepen the knowledge gained so far, further improve technical skills of staff to be trained and to learn more about appropriate quality assurance/quality control in microbiological analysis.

### 3.3. Analysis of metals and pesticides

Both in the planning workshop as well as during the discussion during previous PTB visits to India, it was repeatedly found that capacities to analyse heavy metals (lead, cadmium, nickel, mercury, etc.) and pesticides in the laboratories involved in monitoring the water quality of the Ganga River were weak. Few laboratories have the necessary equipment and personnel to carry out this type of analysis. The intended approach of not building capacity in all state laboratories but concentrating capacity building on a few central or regional laboratories that would then analyse samples from different regions or states is welcomed.

Capacity development activities to strengthen the competence in metal and pesticide analysis will concentrate on APHA methods which are stipulated in the Indian provisions for water quality monitoring. Therefore, preferably Indian experts should conduct the trainings as they, unlike experts from Europe, are familiar with the technical details of APHA methods and apply them regularly.

National (or international) experts will review the methods for the determination of metals and pesticides in surface water to determine whether these methods are suitable for the intended purpose. Furthermore, they will visit some of the laboratories to assess the laboratory facilities and the ability of staff involved in carrying out these types of analyses.

Separate training courses will be held for pesticide and metal analysis. These will include the following topics:

- Extraction techniques and clean-up techniques for pesticides
- Identification and quantification of pesticides using gas chromatography in combination with various detectors including mass spectrometry
- Specific quality assurance/quality control measures in pesticide analysis

- Pre-treatment and digestion (extraction) techniques for metal analysis
- Quantification of metals by inductively coupled plasma optical emission spectrometry (ICP-OES) and by atomic absorption spectrometry (AAS)
- Specific quality assurance/quality control measures in metal analysis

Finally, we will organise training visits for selected laboratory personnel from expert laboratories in India. Those visits aim to deepen the knowledge acquired so far and to improve technical skills of personnel to be trained.

### 3.4. Quality management

Quality management in the laboratories involved in monitoring water quality of the Ganga River is of utmost importance for providing confidence in the produced data. It enables policymakers to take evidence-based decisions for rejuvenation of the river. There are three important fields of quality management, namely formal recognition of competencies (accreditation according ISO/IEC 17025), internal quality control and external quality control (proficiency testing, inter-laboratory studies). PTB would like to cover all three aspects within the project.

Many of the laboratories involved in monitoring the water quality of the Ganga River are already accredited and regularly take part in round robin tests. Nevertheless, the project can support laboratories that are not yet ready for accreditation with training on specific topics that will need to be identified.

Within the framework of the project, at least one inter-laboratory test should be carried out. This could include the basic parameters used in India for water classification. The aim would be to obtain an overview of the performance of the laboratories in the analysis of the most important parameters for water quality assessment.

Another option would be to organise an inter-laboratory comparison for the determination of heavy metals or pesticides in surface water in order to assess the success of the training provided by the project.

Internal quality control is crucial in the laboratories. While the result of an inter-laboratory comparison is a snapshot of a laboratory's performance, internal quality control measures provide evidence that the method used is controlled under routine conditions and that the laboratory produces reliable results day after day. Therefore, training sessions on method validation and the use of control charts (including practical exercises such as the construction of different types of control charts, calculation of measurement uncertainties, etc.) could be conducted with laboratory staff within the context of the project.

### 3.5. Designing monitoring programmes

The planning of monitoring programmes depends entirely on the question to be answered. Possible objectives or questions could be, for example:

- To identify discharges from certain industries
- To detect discharges of untreated domestic wastewater
- Has the construction of a sewage treatment plant led to an improvement in the water quality of the river?
- Are farmers still using a banned pesticide?
- How will the pollution of the river with organic pollutants change over the next 20 years?
- Is the water suitable for bathing or are there any health risks for humans?

Depending on the aim of the monitoring, the following questions will be answered differently:

- What is to be measured?
- Where, when and how often should samples be taken?
- What are the requirements concerning the reliability of the measurement results?

It is therefore worth formulating the objectives of the programme and the questions to be answered as precisely as possible before actually planning the monitoring programme. This is the only way to obtain maximum information from the collected data with minimum effort. In addition, all available information on point and diffuse sources of pollution, water and land use as well as water level and flow should be compiled and used for designing the monitoring programme.

A workshop will be organised to invite international experts to discuss issues like pressure and impact analysis, the objectives of monitoring programmes, the required confidence in the data generated, the use of available information on point or diffuse sources and land use for monitoring design. The objective of this workshop would be to elaborate and agree on recommendations for improving the monitoring programme for the Ganga River and its tributaries.

Furthermore, a dialogue event will be organised to share experiences with experts from other countries on water quality and assessment criteria.

Additional activities, for example regarding real-time water quality monitoring, can be found in the implementation plan below and will be defined in more detail at a later stage.

#### Implementation plan – PTB project *Strengthening Quality Infrastructure for Water Monitoring of the Ganga River*

| Sampling  | How   | Who  | When                     |
|---|---|--|--------------------------|
| Review of existing sampling guidelines and protocols and formulation of recommendations   | Identify international and national experts                             | PTB, supported by NMCG                       | ASAP                     |
|   | Identify and collect guidelines and protocols to be reviewed            | PTB, supported by NMCG, CPCB, Green Tribunal | May 2019                 |
|   | Provide recommendations and discuss them with the competent authorities | PTB expert, respective authority             | July 2019<br>August 2019 |
| Organisation of trainings to strengthen sampling capabilities in line with international best practice (workshops and field training) | Identify organisations/people to be involved in training activities     | NMCG, CPCB, SPCBs and CWC, supported by PTB  | Q3 2019                  |
|   | Organise a workshop on sampling including field training                | PTB together with involved institutions      | Q4 2019                  |
|   | Follow-up on implementation of learned material and recommendations     | PTB expert and trained staff                 | Q1–Q2 2020               |
|   | Organise a follow-up workshop to clarify remaining questions            | PTB together with involved institutions      | Q2 2020                  |

| Testing:<br>Microbiological analysis  | How   | Who                                     | When       |
|---|---|---|------------|
| Evaluation of the laboratories carrying out microbiological analysis by an external expert            | Identify suitable international and national experts  | PTB, supported by NMCG                  | ASAP       |
|   | Identify laboratories/staff to be included  | NMCG, supported by PTB                  | ASAP       |
|   | Organise an expert visit with an initial training session and assessment of further training needs      | PTB together with involved institutions | Q1 2020    |
| Organisation of trainings to strengthen testing capabilities in line with international best practice | Organise workshops at the relevant laboratories tailored to the specific needs of each laboratory       | PTB together with involved institutions | Q2–Q3 2020 |
|   | Identify suitable laboratories (in India or abroad) for training visits of staff                        | PTB                                     | Q3 2020    |
|   | Organise training visits for selected laboratory staff in experienced laboratories (in India or abroad) | PTB together with involved institutions | Q1–Q2 2021 |

| <b>Testing: Heavy metals and pesticides</b>   | <b>How</b>  | <b>Who</b>                              | <b>When</b> |
|---|---|---|-------------|
| Evaluation of the laboratories carrying out heavy metal and pesticide analysis by an external expert  | Identify international and national experts   | PTB, supported by NPL                   | ASAP        |
|   | Identify laboratories/staff to be included  | NMCG, supported by PTB                  | ASAP        |
|   | Organise an expert visit with an initial training session and assessment of further training needs    | PTB together with involved institutions | Q1 2020     |
| Organisation of trainings to strengthen testing capabilities in line with international best practice | Organise workshops at the relevant laboratories tailored to the specific needs of each laboratory     | PTB together with involved institutions | Q2–Q3 2020  |
|   | Identify suitable laboratories for training visits of staff   | PTB                                     | Q3 2020     |
|   | Organise training visits for selected laboratory staff in experienced laboratories in India or abroad | PTB together with involved institutions | Q1–Q2 2021  |

| <b>Quality management</b>  | <b>How</b>   | <b>Who</b>                              | <b>When</b>     |
|--|--|---|-----------------|
| Trainings on internal quality control                            | Identify suitable laboratories to be included  | NMCG, supported by PTB                  | May 2019        |
|  | Organise a workshop on internal quality control including concrete practical exercises                           | PTB together with involved institutions | August 2019     |
|  | Conduct laboratory audits to identify the concrete needs of the laboratories                                     | PTB                                     | Q3–Q4 2019      |
|  | Follow-up on internal implementation of learned material and recommendations                                     | PTB expert                              | Q4 2019–Q1 2020 |
| Organisation of proficiency tests for relevant parameters        | Define parameters for proficiency testing (suggestion to use the most relevant parameters in the Indian context) | NMCG, supported by NPL, CPCB and PTB    | ASAP            |
|  | Identify laboratories to be involved   | NMCG, supported by NPL, CPCB and PTB    | ASAP            |
|  | Organise proficiency test and evaluation workshop  | NPL and/or CPCB, supported by PTB       | 2020            |
|  | Organise second round of proficiency tests for additional parameters (e.g. metals, pesticides)                   | NPL and/or CPCB, supported by PTB       | 2021            |
| Assistance in achieving accreditation according to ISO/IEC 17025 | Identify laboratories which need assistance  | NMCG, supported by PTB                  | ASAP            |
|  | Organise tailored workshop with selected laboratories  | PTB together with involved institutions | TBD             |

| <b>Strengthen state laboratories</b>   | <b>How</b>  | <b>Who</b>                              | <b>When</b> |
|--|---|---|-------------|
| Consultancy of laboratories as required (for procurement, set-up, site acceptance tests, additional materials and equipment, etc.) | Identify consultancy needs  | NMCG, supported by PTB                  | ASAP        |
|  | Review documents as requested   | PTB together with involved institutions | TBD         |
|  | Organise a workshop on business planning or another relevant topic as requested | PTB together with involved institutions | TBD         |

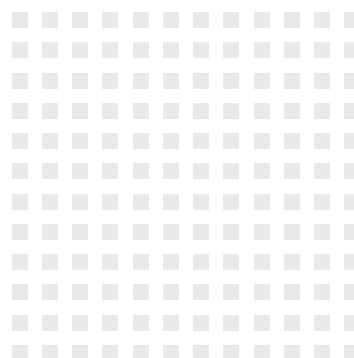
| <b>Designing programmes</b>   | <b>How</b>   | <b>Who</b>             | <b>When</b> |
|---|--|------------------------|-------------|
| Workshop on strategies of designing monitoring programmes                           | Identify concrete needs for monitoring programme design  | NMCG, supported by PTB | ASAP        |
|   | Organise tailored workshops addressing topics such as pressure-impact analysis, objective of the monitoring, required confidence | PTB, supported by GIZ  | Q3–Q4 2019  |
|   | Formulate recommendations on improvement of existing monitoring programmes   | PTB expert             | Q1 2020     |
| Exchange of experiences with experts from other countries on water quality criteria | Identify suitable experts  | PTB                    | ASAP        |
|   | Organise a dialogue event  | PTB, GIZ, WRG 2030     | 2020        |

| <b>Real time monitoring</b>                            | <b>How</b>  | <b>Who</b>                | <b>When</b> |
|--|---|---------------------------|-------------|
| Recommendations on use of real time monitoring systems | Formulate recommendations   | PTB expert                | TBD         |
|  | Further suggestions by NMCG   | NMCG                      | ASAP        |
| Validation of monitoring data                          | Assess existing gaps in data validation; show examples from EU; and provide recommendations for improving the data entry system | PTB expert                | Q3–Q4 2019  |
|  | Pilot the software upgrade / new features on a limited data set   | PTB expert, NMCG and CPCB | 2020        |

| Transversal activities                                      | How  | Who                    | When        |
|---|--|------------------------|-------------|
| Implementation Agreement                                    | Signing of the implementation agreement  | NMCG and PTB           | May 2019    |
| Steering Committee  | Form a steering committee chaired by NMCG  | NMCG and PTB           | Q3 2019     |
|   | Organise a first steering committee meeting  | NMCG, supported by PTB | August 2019 |
| Communication of project activities                         | Regular mailing of newsletters (approx. every 3 months), workplans and progress reports (approx. every 6 months).<br>Printing of relevant information material (e.g. newsletters). | PTB                    | Ongoing     |
|   | Publish information about project activities on NMCG and PTB website   | PTB and NMCG           | Ongoing     |
| Multi-stakeholder events                                    | Organisation of network meetings to support the exchange between relevant agencies<br>→ Discuss progress and expectations  | NMCG and PTB           | End of 2019 |
| 1 <sup>st</sup> study visit to Germany for management level | PTB to suggest activities.<br>Organise study visit.  | PTB and NMCG           | TBD 2019    |
| Possible 2 <sup>nd</sup> study visit                        | Could be funded by NMCG  | PTB and NMCG           | TBD         |

This plan needs to be discussed during steering committee meetings and updated every six months by PTB and NMCG.

The geographical focus of the project activities is primarily the states of Uttarakhand and Uttar Pradesh.



# Abbreviations

|               |   |
|---------------|---|
| BGR           | German Federal Institute for Geosciences and Natural Resources  |
| BOD           | Biochemical Oxygen Demand   |
| cGanga        | Center for Ganga River Basin Management and Studies   |
| CPCB          | Central Pollution Control Board   |
| CWC           | Central Water Commission  |
| EQS           | Environmental Quality Standards   |
| GIZ           | Deutsche Gesellschaft für Internationale Zusammenarbeit<br>(German Society for International Cooperation) |
| IEC           | International Electrotechnical Commission   |
| IITR          | Indian Institute of Toxicology Research   |
| ISO           | International Standards Organisation  |
| KfW           | Kreditanstalt für Wiederaufbau (German Development Bank)  |
| MoWR, RD & GR | Ministry of Water Resources, River Development and Ganga Rejuvenation                                     |
| NABL          | National Accreditation Board for Testing & Calibration Laboratories                                       |
| NEERI         | National Environmental Engineering Research Institute   |
| NGO           | Non-Governmental Organisation   |
| NISE          | National Institute of Solar Energy  |
| NMCG          | National Mission for Clean Ganga  |
| NPL           | National Physical Laboratory (the National Metrology Institute of India)                                  |
| NRCD          | National River Conservation Directorate   |
| PSI           | People's Science Institute  |
| PTB           | Physikalisch-Technische Bundesanstalt (the National Metrology Institute of Germany)                       |
| RTWQMS        | Real-Time Water Quality Monitoring System   |
| SI units      | International System of Units   |
| SPCB          | State Pollution Control Board   |
| WFD           | European Water Framework Directive  |
| WWF           | World Wildlife Fund   |

# Annex 1 – Workshop Agenda

| Time                        | Session/activity  |
|-----------------------------|---|
| 10:00–10:30                 | Registration & reception  |
| 10:30–11:00                 | High tea/coffee break   |
| <b>Inaugural Session</b>    |   |
| 11:00–11:10                 | Welcome speech:<br>Sh. Rajiv Kishore, ED (Admin.), NMCG   |
| 11:10–11:20                 | Address by:<br>Sh. Rajiv Ranjan Mishra, Director General, NMCG  |
| 11:20–11:30                 | Address by:<br>Mr. Wolfgang Köster, Deputy Head of Economic Cooperation & Development, German Embassy   |
| 11:30–11:40                 | Vote of thanks:<br>Sh. D.P. Mathuria, Executive Director Technical, NMCG  |
| <b>Technical Session I</b>  |   |
| 11:40–12:10                 | Presentation on the project:<br>Mr. Patrick Dolle, project coordinator  |
| 12:10–12:40                 | Presentation on the EU Water Framework Directive:<br>Dr. Peter Lepom, PTB expert  |
| 12:40–13:30                 | Presentation on water quality monitoring in India:<br>Sh. R.M. Bhardwaj, consultant (IP), NMCG<br>Sh. A. Sudhakar, Additional Director & In-charge, WQM-I, CPCB<br>Dr. Sanjeev Agrawal, Additional Director & In-charge, Biological Lab, CPCB |
| 13:30–14:30                 | Lunch break   |
| <b>Technical Session II</b> |   |
| 14:30–15:00                 | Presentation on suggested activities of the PTB project:<br>Ms. Katharina Telfser, PTB expert   |
| 15:00–16:30                 | Presentations by stakeholders (moderated by Mr. Patrick Dolle):<br>UEPPCB, UPPCB, BSPCB, JSPCB, WBPCB, 5-Ganga SPMGs, DPCC, HSPCB, MoEF&CC, CWC, GIZ, CP, WWF, PSI, NIH, cGanga   |
| 16:30–17:00                 | Coffee/tea  |
| <b>Concluding Session</b>   |   |
| 17:00–17:30                 | Summary of the workshop, proceedings & final remarks:<br>Chaired: DG, NMCG; Co-chaired: ED (T), ED (Admin), ED (P), ED (F), NMCG; PTB   |



## Annex 2 – Participant List

| <b>Name</b>             | <b>Organisation</b>  |
|-------------------------|--|
| Amit Pokhriyal          | Uttarakhand Environment Protection and Pollution Control Board   |
| Dr. Ajeet Singh         | Uttarakhand Environment Protection and Pollution Control Board   |
| S. N. Jayaswal          | Board Analyst, Bihar State Pollution Control Board               |
| Dr. Ashok Kumar         | Incharge-Control Lab, Uttar Pradesh Pollution Control Board      |
| Saurabh Kumar           | Physikalisch-Technische Bundesanstalt (PTB), consultant          |
| Anil Gautam             | People's Science Institute Dehradun                              |
| Anita Sharma            | People's Science Institute Dehradun                              |
| Ajay Kumar              | EE, USS Dehradun Uttarakhand                                     |
| Patrick Dolle           | Physikalisch-Technische Bundesanstalt (PTB), project coordinator |
| Dr. Peter Lepom         | Physikalisch-Technische Bundesanstalt (PTB), consultant          |
| Katharina Telfser       | Physikalisch-Technische Bundesanstalt (PTB), consultant          |
| P. K. Sharma            | Central Water Commission   |
| Ziaul Hoda              | GIZ India  |
| Christiane Hieronymus   | German Embassy   |
| Dr. S. Swarupa          | National Physical Laboratory (NPL) India                         |
| Conrad Steinhilber      | KfW  |
| Sandeep Kashyap         | Uttarakhand Pey Jal Nigam, Rishikesh                             |
| Annelieke Laninga       | 2030 Water Resource Group  |
| Vinod Tare              | cGanga, IIT Kanpur   |
| Ravi Shanker            | Central Water Commission   |
| Dr. Jakir Hussain       | Central Water Commission   |
| Dr. Ben N. Jacobsen     | GIZ, consultant  |
| Laura Susterna          | GOPA   |
| John Thomas             | GOPA   |
| Priyanka Saxena         | CSIR-NEERI   |
| Merajuddin Ahmad        | GIZ-SGR Dehradun   |
| Pascal Saaredra-Lux     | KfW  |
| Priyanka Chaudhary      | Central Pollution Control Board                                  |
| Mehar Puri              | WWF India  |
| Carlos Benitez          | GIZ, consultant  |
| Birgit Vogel            | GIZ India  |
| Sanjay Kumar Srivastava | Jharkhand State Pollution Control Board, Ranchi                  |
| Martina Burkard         | GIZ India  |
| Wolfgang Köster         | German Embassy   |
| Kiran Aradhanula        | KfW  |

# Annex 3 – Stakeholder Map

Stakeholders that were identified as important for the project by 5–6 stakeholders are marked in **blue and bold**. Stakeholders with 3–4 votes are marked in **blue**.

|   |  |
|---|--|
| <b>National level</b>   |  |
| National Council for Rejuvenation, Protection and Management of River Ganga<br>(National Ganga Council headed by Prime Minister)  |  |
| <b>Ministry of Water Resources, River Development and Ganga Rejuvenation</b>  | <b>Ministry of Environment, Forests and Climate Change</b>   |
| <b>National Mission for Clean Ganga (NMCG), Central Water Commission (CWC), Empowered Task Force (of the National Ganga Council), Water Quality Assessment Authority (under MEFCC until 2015)</b>   | <b>Central Pollution Control Board (CPCB), National Water Quality Monitoring Network (CPCB &amp; SPCBs)</b>  |
| <b>State level</b>  |  |
| <b>State Ganga Committees (Authority), State-Level Water Quality Authorities, State Programme Management Groups (SPMG), State Urban Development Department, Agriculture Department of State, State Water Resource Department, Irrigation Departments, Jal Boards</b>  | <b>State Pollution Control Boards (SPCB), Pollution Control Committees (PCCs), State Environment Board, State Water Utilities (Jal Migum/Jal Sansthem)</b>   |
| <b>Quality infrastructure and research institutions</b>   | <b>International organisations and NGOs</b>  |
| <b>National Accreditation Board for Testing &amp; Calibration Laboratories (NABL), National Environmental Engineering Research Institute (NEERI), Center for Ganga River Basin Management and Studies (cGanga), Council of Scientific and Industrial Research (CSIR), Indian Institute of Toxicology Research, Lucknow (IITR), National Institute of Hydrology (NIH), National Physical Laboratory (NPL), Doon University Uttarakhand</b> | <p><b>Multilateral cooperation:</b><br/>EU, UNDP, World Bank</p> <p><b>Bilateral cooperation:</b><br/><b>Germany</b>, Australia, Belgium, Canada, Denmark, Finland, Israel, Japan, Netherlands, UK</p> <p><b>NGOs:</b><br/>People’s Science Institute (PSI), World Wildlife Fund (WWF), CEDAR in Dehradun</p> <p><b>Educational institutions:</b><br/>ISM, Ahanbad, BIT, Mesra, Ranchi, Private University – UPES Department of Environment</p> <p><b>Other:</b><br/>Wildlife Institute of India (WII)</p> |

# Notes

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