UNESCO Workshop on Greenhouse-Gas Emissions from Freshwater Reservoirs

United Nations Educational, Scientific and Cultural Organization, Paris, France
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Statement by Workshop Participants

Rationale

The proposed methodology from the Intergovernmental Panel on Climate Change (IPCC) for estimating a national inventory of anthropogenic greenhouse-gas (GHG) emissions from freshwater reservoirs has met with differing views. The debate associated with GHG emissions from freshwater reservoirs is not focussed on the fact that emissions occur; the debate is on the incremental proportion, if any, that is related to human activity (both as a result of the impoundment, and as a result of human activities in the upstream watershed).

In January 2006, the Executive Board of the UN Framework on the Convention on Climate Change (UNFCCC) Clean Development Mechanism introduced criteria that exclude hydropower schemes with significant water storage from this mechanism. The decision was taken as a precautionary measure, pending further clarification of reports in the scientific literature on GHG emissions associated with freshwater reservoirs.

Note: The UNESCO Workshop on GHG Emissions from Freshwater Reservoirs was organized as part of UNESCO IHP-VI (2002-2007), which includes a theme dealing with Global Changes and Water Resources. In this context, UNESCO provided a forum for the debate of the scientific aspects of GHG emissions from freshwater reservoirs. Please note that presentations and statements by participants are the responsibility of participants and UNESCO does not necessarily endorse the views of any individual participant, nor the collective conclusions of the workshop.

Scope

The UNESCO Workshop on GHG Emissions from Freshwater Reservoirs brought together government officials, scientists and reservoir managers to:

- Review previous and current research and field measurements
- Assess common understanding and identify knowledge gaps
- Define future research needs
- Identify roles for future work

Status of Research Findings

Workshop participants reviewed the findings of previous research and field studies conducted over the last decade up to the present. Reports were presented by scientists that had been directly responsible for the particular studies. Studies included work in Northern Europe (Finland and Norway), North America (Canada and USA) and Latin America (Brazil, French Guyana and Panama). Therefore, the review covered cold (boreal), temperate and tropical climate types. Although, more than a hundred existing reservoirs have been studied, only a limited number (about 10% of published data) are in the tropical zone. For this zone, it was noted that the research was exclusively related to Latin America.

The following GHG species had been considered in the studies: nitrous oxide (N_2O), carbon dioxide (C_2O) and methane (CH_4).

Common Understanding

The first common understanding is that what should be considered is the reservoir induced change, that is, the net change of GHG emissions across the river basin, compared to natural emissions that would have occurred anyway, or the effect of other human induced emissions.

With regards to the three species of gases, the participants concluded the following:

- Data were presented on the recordings of N_2O related to freshwater reservoirs in each of the major climate types. Very small N_2O emissions had been recorded. It is well established that the major sources of nitrogen are agricultural fertilizers and urban waste discharges coming from the upstream watershed. It was concluded that N_2O emissions need not be included in future reservoir induced GHG research.

- For CO_2, it was noted that emissions measured at the reservoir surface largely represented the product of the natural carbon cycle. In a small number of temperate and cold/boreal reservoirs, absorption of CO_2 had been recorded at the reservoir surface. Measurements on newly created reservoirs showed an increase of CO_2 emissions with peak values during the first years after impoundment. It was understood that this pulse represented the decomposition of submerged flora, although a substantial portion of the remaining biomass will not decompose and will be preserved by the reservoir water. Another source of the CO_2 is the release of carbon from soils in the drawdown zone. In all reservoirs, the peak of this activity occurred generally within the first two or three years after commissioning. It was agreed that the net CO_2 emissions were not significant in relation to the lifespan of most reservoirs.
- CH_4 is the most significant GHG in relation to reservoirs. In cold/boreal and temperate reservoirs, little CH_4 emissions have been recorded. In some cold/boreal reservoirs, CH_4 emissions have been detected following the break-up of the winter ice cover. In some tropical reservoirs, however, significant CH_4 emissions have been recorded. There is a high temporal variability in CH_4 emissions, which needs further investigation. In at least one case (Petit Saut, French Guyana), significant CH_4 'degassing' emissions have been recorded downstream of the reservoir. However, based on a limited set of published measurements, it seems that some tropical reservoirs exhibited very low CH_4 emissions.

Knowledge Gaps and Research Needs

A better understanding of the CH_4 footprint of tropical reservoirs is required. This is where future research efforts should be focussed. It appears that deep water reservoirs tend to have low CH_4 emissions. For shallow reservoirs, criteria which determine the likelihood of methane emissions need to be clarified. The variability of fluxes needs further scientific investigation. The observation of CH_4 appeared to relate to the existence of substantial and persistent anoxic bodies of water, especially near the surface of the reservoir.

Anoxia might be influenced by factors such as the input of organic material from upstream, reservoir shape and depth, hydrology, dam operation, altitude, local meteorological conditions and trophic conditions (nutrient levels). Currently, a predictive model has been developed, but further validation is required. Better understanding and ranking of these criteria is required.

There is evidence that CH_4 formation in reservoirs produces a by-product of carbon compounds (phenolic and humic acids) that are effectively sequestrated by the reservoir. The methods to measure this should be investigated further. It might well be that some reservoirs could be carbon sinks. The extent to which this process off-sets the impact of methane production requires further scientific investigation. Also, it appears that an upper layer of oxygenated water plays a major role in the oxidation of CH_4 as it ascends from the lower levels of the reservoir. However, it should be kept in mind that the oxidation process will deplete the levels of oxygen in this upper layer.

There continues to be limited knowledge relating to the CH_4 emissions of the pre-impoundment area. Research can either be carried out in the area before impoundment, or on 'proxy' areas that are similar in nature to land that has already been submerged. Care needs to be taken to capture the net emissions from the ecosystem under investigation, and not just the respiration from the soil, and also carbon or nutrient inputs from the upstream area. Past research has indicated some incidence of high CH_4 emissions from natural floodplains, wetlands, and other areas. CH_4 emissions from these areas may be suppressed after reservoir inundation by oxidation as the CH_4 rises through the covering water column. The suppression of CH_4 under such circumstances requires further investigation.

Monitoring of CH_4 emissions in areas upstream and downstream of reservoirs is required. CH_4 degassing from outlets which drain anoxic reservoir water may significantly contribute to the total emissions. Research is needed to identify how commonly this situation occurs at existing schemes.

In cases where CH_4 emissions are likely to be an issue, reservoir designers and operators must be better informed of possible mitigation measures to reduce these emissions. Research into mitigating measures is necessary.

A particular goal is to develop a rigorous and standardized procedure to evaluate CH_4 emissions induced by existing and planned reservoirs, with a special focus on the tropical areas.

Roles for Future Work

While reservoirs in cold (boreal) and temperate climates have a very low GHG footprint, there is a clear demand to obtain a better understanding of the CH_4 impact of reservoirs in the tropical region. While some tropical reservoirs also have very low CH_4 emissions, others, especially shallow, plateau type, reservoirs appear to emit large amounts.

The need to manage surface water in the tropics is pressing, and reservoirs for all purposes will continue to be developed in the region. From the point of view of power generation, the majority of the world's hydropower potential remains in the tropics. Therefore, it is essential to close the knowledge gaps and establish best practice.

Reservoir operators and developers working in the tropical region are willing to engage with the scientific community in a focussed programme of field measurement, leading to outcomes that clearly define the CH_4 footprint of existing and new reservoirs. This process must be transparent and credible and lead to publications that can be used by operators, the scientific community, national and international bodies, enabling accurate reporting of GHG emissions and informed decisions.

The participants of this workshop wish to pursue the dialogue within a reservoir emissions forum, coordinated by a steering committee, with the aim of quantifying net GHG fluxes associated with reservoirs.

This forum should identify the monitoring and methodology required to assess the CH_4 impact of typical and shallow tropical reservoirs. To ensure a common approach and more efficient processes, reservoir operators should communicate efforts through a specific steering committee. The predictive modelling of future reservoirs and their influence on the change of GHG emissions from the river basin must be validated through a similar process.

The proposed structure for the steering committee is:

- 2 to 4 Government representatives
- 2 to 4 Scientists
- 2 to 4 Reservoir operators
- 1 Neutral host

Footnote: River basins are taken to include the system upstream and downstream

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