The Missing Link: Contribution of Small Floodplain Tributaries to the Nutrient Budget of Ganga River

Soumita Boral
Indian Institute of Technology, Kanpur
Email: soumita@iitk.ac.in

Calm and persistent, rivers are truly physical marvels, the only way deep interiors of the continental landmass stay connected to the oceans. They have been an integral part of human civilization and continue to be one of the most important resources. But in the flowing waters and in the sediment shield is hidden a plethora of information related to earth's landscape, geology, climate as well as the impact of ongoing human activities on the environment. Metal, plastic and organic pollution have deteriorated the health of most rivers across the world. Infact, the industrial civilization has brought many rivers to the tipping point and further changes would be unpredictable and irreparable, thus, quite alarming. Therefore, many governments have planned river restoration projects to address the challenges in river basin management.

In India, Ganga River is at the focal point of such restoration programs, as it is ranked in the top three most polluted rivers in the world for many years now. It is estimated that 85% (~95m^3/s) of waste generated from 222 towns is discharged untreated into Ganga River while the rest 15% is dumped onto land. Several missions to "Clean Ganga" over the last two decades and even "Zero liquid Discharge" policy have been implemented at few places. Though this policy would curb the entry of pollutants from point-sources such as industrial sewage and municipal effluents, non-point source contribution continues. Pollution via small seasonal tributaries and groundwater flux are such non-point source contributors and often go unnoticed in the bigger programs. Small catchment area and lower annual discharge seems to diminish the importance of such seasonal tributaries.

* Ms. Soumita Boral, Ph.D. Scholar from Indian Institute of Technology, Kanpur, is pursuing her research on "River Linkages to the Glaciers and Oceans." Her popular science story entitled "The Missing Link: Contribution of small Floodplain Tributaries to the Nutrient Budget of Ganga River" has been selected for AWSAR Award.

Another emerging concern is the increased rate of fertilizer based agricultural activities in the Indo-Gangetic flood plains. Phosphates (P) and Nitrogen(N) compounds are primary nutrients and their deficiency could limit primary production. But in excess these nutrients cause eutrophication, acidification, algal blooms and hypoxia. Thus, nitrogen and phosphorus cycling is very well studied in oceans and also formany rivers in the world. In fact, long-term nitrogen and phosphorus concentrations in river water have proven how human activities have driven the riverine nitrogen and phosphorus loads. For example a study published in Biogeochemistry journal by Green et al., in 2004 showed that riverine contribution to global ocean increased by six times from preindustrial (N~ $2.1*10^6$ /yr) to contemporary times (N~ $14.5*10^6$ /yr). The decrease in fertilizer application has also shown to reduce the average nitrate concentration in some European rivers.

Currently, we lack holistic understanding about the fate of excess nitrogen and phosphorus from the fertilizers, their internal cycling and transport pathways to the Indo-Gangetic floodplains, groundwater and to the tributaries as surface runoff from cultivated lands. Here's where research from our group in the Department of Earth Science at Indian Institute of Technology Kanpur comes in. My research specially is using river and sediment on the different aspects of glacier-land-river-ocean pathways and processes. To address the above discussed problem, we monitored the Pandu River which is a right bank tributary of Ganga River. There are several small seasonal tributaries in the entire Indo-Gangetic flood plains. The hypothesis of the study was small tributaries in the Indo-Gangetic flood plains have higher nutrient loads and their collective contribution to Ganga would be influencing the river chemistry of this large river. Pandu River is 242km long with a catchment area of 1495km^2, of which 95% is agricultural land. It is mainly fed by rainwater during the Indian summer monsoon and surface runoff from surrounding irrigated lands. This river was monitored from February 2015 to April 2016. We measured dissolved silicate, phosphate, nitrate, nitrite and ammonium concentrations along with discharge. Nitrate, nitrite and ammonium are collectively called as the dissolved inorganic nitrogen (DIN). We found that, silicate, DIN and phosphate concentrations to vary between 6.99 -21.48, 0.6-7.23, and 0.08-4.58 mg/L respectively. Such concentrations are higher than most monsoonal rivers in India. The DIN, silicate and phosphate yields were 0.53, 1.08 and 0.118 t/km^2/yr, respectively. The only rivers having higher DIN than Pandu River, in India were rivers Haldia, Netravati and Zuari. In global comparison, Pandu River has higher phosphate yield than Amazon (0.009t/km^2/yr) and Yangtze (0.027 t/km^2/yr). Here it is important to note that differences in agricultural practices, waste management, effluent discharge policies, cropping intensities due to the socio-economic conditions of this river basin is unique and comparing these statistics with other river basins would be quite complex.

We estimated that Pandu River exports 177±29 t/yr of phosphate and 793±128 t/yr of DIN to Ganga River, which amounts to 0.42%and 0.1% of phosphate and DIN fluxes from Ganga River to the Bay of Bengal. Since Pandu River contributes only 0.03% of the total Ganga River water discharge to the Bay of Bengal, Pandu River carries relatively high phosphate and DIN loads. Since phosphate and DIN loads are dependent on human activities, we used fertilizer application rates per square area, irrigated land area and population density as metrics of estimating the representativeness of Pandu River and scale up the results for the entire Indo-Gangeticfloodplains.

By comparing these data from Pandu basin with 118 districts in the Indo-Gangeticfloodplains which cover 89% of Ganga Basin, we estimated the collective contribution from small tributaries. We estimated that small rivers collectively would annually export 1,15,903 and 25,706 t/yr of DIN and phosphates to Ganga River. This is 15% and 61% of the total DIN and phosphate fluxes from Ganga River to the Bay of Bengal.

Therefore, small floodplain tributaries do contribute significantly to the chemistry of large rivers and are an important source of non-point source pollution. Despite their importance these rivers were seldom studied and are now being recognized as potential contributors. Therefore, this work demonstrated the need for additional assessments of small streams with long- term monitoring policies and counting their contribution to the large rivers. This information would be critical in planning and implementing remediating efforts, and would help the water resource policy managers to better restore the river health and adapt to changes of land-use in the future.