Assessing the water quality of Himalayan glacier-fed rivers

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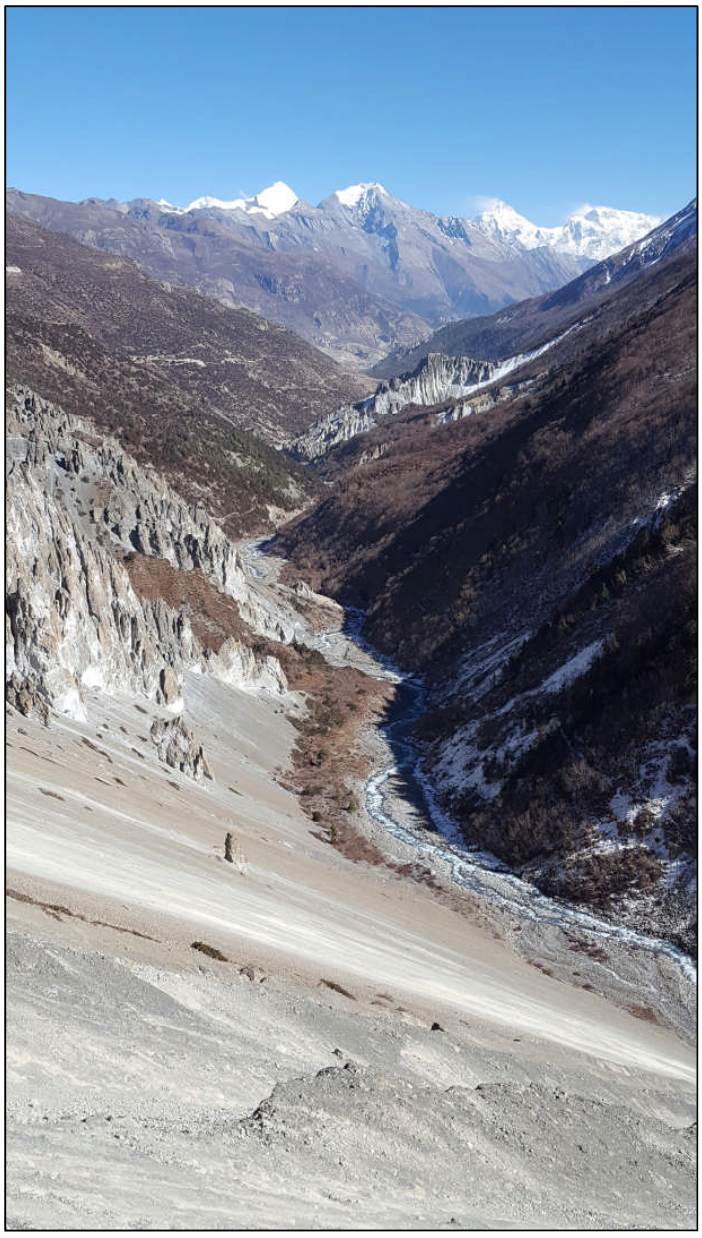
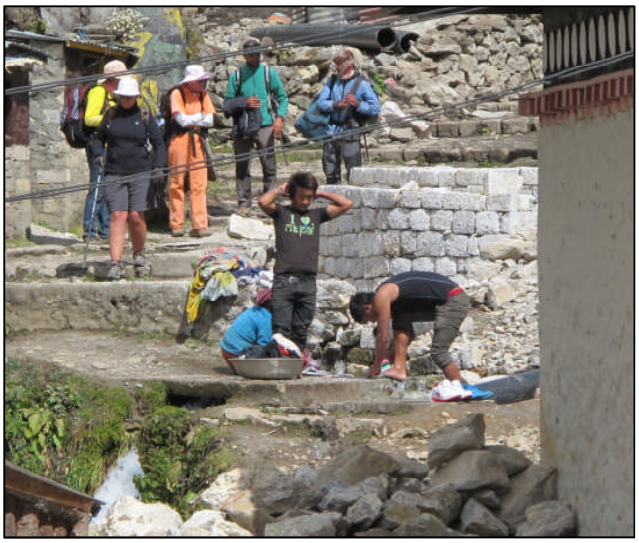
More than 1.4 billion people depend on water from the rivers of the Himalaya (Immerzeel et al., 2010) and there are more than 6000 rivers flowing from the Himalayan Mountains to the hills and plains in Nepal (CBS, 1995). Most of these rivers are glacier fed and provide sustained flow during the dry season to meet the water requirements for those living downstream (Ghimire et al., 2013). While much research has focussed on the impact of climatic changes on the timing and magnitude of water supplies to downstream areas (e.g. Lutz et al., 2014), much less attention has been devoted to the impact of anthropogenic pollution on the water quality of these mountain streams and rivers.



Studies have shown that pollution of lowland rivers in Nepal increases with distance from the mountains and with proximity to urban centres, due to increasing population, agricultural activity and inputs of effluent from industry and untreated sewage (e.g. Mishra et al., 2017). Much less is known about the water quality of remote mountain areas, yet in these parts surface water may be used directly for irrigation, sanitation, and in some cases, consumption. Historic datasets collected during the early 1990s in the Khumbu, Annapurna and Langtang catchments (Reynolds et al., 1995; 1998) show that the bedrock geology was the primary driver of the spatial variability in water chemistry in these regions. However, although stream water nitrate concentrations were generally small, large values were recorded in some areas and there was a positive correlation with altitude suggesting either a larger atmospheric deposition at higher altitude and/or that uptake of nitrate by both terrestrial and aquatic systems decreased with altitude. Subsequent surveys of water bodies in the Khumbu region in 2008, 2009 and 2010 showed that both nitrate and phosphate concentrations have increased since 1992 and

over the period 2008-2010 (Ghimire et al., 2013).

Additionally, over the last 25 years, these mountain areas have faced increasing anthropogenic pressures from population growth, increase in tourism, land use change, atmospheric pollution and climate change. Such pressures are likely to have had an impact on water chemistry and quality via an associated increase in sewage waste, fertiliser use, atmospheric deposition of sulphur, nitrogen and heavy metals and in non-biodegradable solid waste such as plastic containers and batteries. In addition to increasing nutrient and metal concentration, these pressures may also lead to the presence of microplastics and other emerging pollutants (EPs), such as pharmaceuticals, which have not yet been monitored in remote mountainous streams but have the potential to enter the environment and cause adverse ecological and human health effects.



The major aim of this project will be to evaluate contemporary water quality in major mountain regions of Nepal, and establish how this compares with the chemistry of surface waters that were originally surveyed in the early 1990s. This 30 year temporal analysis will be the first of its kind in this region, and has the potential to bring the issue of water quality, and how it will change with continued pressure on resources, to the forefront of the policy agenda.

Objectives

In this project, you will work with scientists at the University of Leeds to quantify the impact of different anthropogenic pressures on water chemistry and aquatic ecosystems in one or more of the Khumbu, Annapurna and Langtang regions of Nepal. This will be achieved through fieldwork in Nepal and subsequent laboratory analysis on return to Leeds. In particular, according to their particular research interests, the successful student could:

1. Determine how surface water nutrient concentrations have changed over time with variations in discharge and routing;
2. Investigate whether microplastics and other emerging contaminants are present in aquatic ecosystems of the source areas that feed major rivers of the region;
3. Evaluate which anthropogenic pressures are having the most significant impact on water quality and how this will evolve with future changes in supply.

Fit to NERC Science

This project is aligned to the NERC 'Pollution, waste and resources' and 'Terrestrial and freshwater environments' research area. Specifically the project aligns to the following NERC research areas: (1) **Pollution** – by determining whether anthropogenic pressures in the mountainous regions of Nepal are

leading to the pollution of surface waters (2) **Water quality** – by ascertaining the major controls on water chemistry and (3) **Biogeochemical cycles** – by considering the fluxes and cycling of matter within and between the biosphere and the physical environment (4) **Ecosystem scale processes** – in particular the interaction between land use and water quality.

Potential for high impact outcome

The project will enable significant, timely advancements to be made in understanding the impact of anthropogenic pollution on surface waters in mountainous regions of Nepal. These areas are almost entirely unstudied, yet have a direct impact on the quality of life of those people dependent on the surface waters for their irrigation and sanitation needs. The project will produce several outputs, including (i) 3–4 academic publications, at least one of which we anticipate being suitable for submission to a high-impact journal and (ii) a major contribution to the management plan of the river water ecosystems in the National Parks of Nepal.

Training

The student will work under the supervision of Dr Duncan Quincey, Professor Pippa Chapman, and Dr Paul Kay within the River Basin Dynamic and Management research cluster in the School of Geography, University of Leeds. The successful candidate will develop a range of research skills, including experimental design, field sampling, chemical analysis, statistical analysis and data interpretation, academic writing skills and giving presentations. Training will be provided in field/laboratory health and safety procedures and the use of field and analytical equipment.

The student will be supported throughout the studentship by a comprehensive PGR skills training programme that follows the VITAE Research Development Framework and focuses on knowledge and intellectual abilities; personal effectiveness; research governance and organisation; and engagement, influence and impact. Training needs will be assessed at the beginning of the project and at key stages throughout the project and the student will be encouraged to participate in the numerous training and development course that are run within the NERC DTP and the University of Leeds to support PGR students, including statistics training (e.g. R, SPSS), academic writing skills, grant writing etc (http://www.emeskillstraining.leeds.ac.uk/). Supervision will involve regular meetings between all supervisors and further support of a research support group.

Student profile

The student should have a keen interest in environmental issues with a strong background in a physical geography, earth sciences, environmental sciences, chemistry or related discipline. Strong analytical/statistical/fieldwork/laboratory skills are desirable but not essential, as full training will be provided during the PhD.

References

CBS, 1995. Statistical Year Book of Nepal, CBS, Kathmandu.

Ghimire, N.P., Jha, P.K. and Caravello, G., 2013. Physico-chemical parameters of high-altitude rivers in the Sagarmatha (Everest) National Park, Nepal. *Journal of Water Resource and Protection*, *5*(08), pp.761.

Immerzeel, W.W., Van Beek, L.P.H. & Bierkens, M.F.P. 2010. Climate change will affect the Asian water towers. *Science*, 328, pp.1382–1385.

Lutz, A.F., Immerzeel, W.W., Shrestha, A.B. & Bierkens, M.F.P. 2014 Consistent increase in High Asia's runoff due to increasing glacier melt and precipitation. *Nature Climate Change*, 4, pp.587–592.

Mishra, B.K., Regmi, R.K., Masago, Y., Fukushi, K., Kumar, P. and Saraswat, C., 2017. Assessment of Bagmati River pollution in Kathmandu Valley: scenario-based modeling and analysis for sustainable urban development. *Sustainability of Water Quality and Ecology*, *9*, pp.67-77.

Reynolds, B., Chapman, P.J., French, M.C., Jenkins, A. and Wheater, H.S., 1995. Major, minor, and trace element chemistry of surface waters in the Everest region of Nepal. *IAHS Publications-Series of Proceedings and Reports-Intern Assoc Hydrological Sciences*, *228*, pp.405-412.

Reynolds, B., Jenkins, A., Chapman, P.J. and Wilkinson, J., 1998. Stream Hydrochemistry of the Khumbu, Annapurna and Lantang Regions of Nepal, In: *Top of the World Environmental Research*: *Mount Everest-Himalayan-Ecosystem*, Backhuys Publishers, Leinden, pp.123-140.