TOPIC: GROUNDWATER ARSENIC POLLUTION

SUB-TOPIC:
PART C: MYANMAR CASE STUDY

Supporting Transcript

PRESENTED BY: Laura Richards, The University of Manchester
COURSE COORDINATOR: Dr. Laura Richards, The University of Manchester (Department of Earth and Environmental Sciences)

This transcript accompanies associated presentation slides and video content developed for the TIDE project in 2021, with acknowledgements and disclaimer as noted in associated files.

SLIDE 1

Hello my name is Dr Laura Richards of the Department of Earth and Environmental Sciences at The University of Manchester. The third mini lecture in this series on arsenic pollution and groundwater will cover a case study of some of our recent research in Myanmar.

SLIDE 2

I will start with a very brief introduction and recap followed by a discussion of this case study in Myanmar and a quick overall summary.

SLIDE 4

As George has covered in the previous lessons, arsenic is mobilized in groundwater in South and Southeast Asia by several different processes however the most common process is by the reductive dissolution of arsenic bearing iron and manganese minerals, particularly iron hydroxides. So when arsenic is trapped in sediment it poses a relatively low risk, however when there are sources of bioavailable organic carbon and metal reducing bacteria arsenic can become mobilized via the reductive dissolution of iron or manganese hydroxide sediments. When arsenic is mobilized into groundwater it becomes a potential major risk to people who can be exposed via drinking or cooking or also through other pathways. Chronic exposure to arsenic exceeding the World Health Guideline values or even lower concentrations can lead to detrimental health impacts.

SLIDE 5

We know that concentrations of arsenic can be highly heterogeneous. That means that there can be a lot of variability even on small spatial scales. For example here are some results from a separate study in Cambodia where the circles represent concentrations. You can see that there's a high degree of variability in concentrations even at one site with depth. For example at this site here concentration ranges from less than 10 up to almost 700 and at sites, you know only a couple of kilometers away, the picture can look very different as well.
SLIDE 6

So although it's very very useful that there are predictive tools including the gap maps platform which I know George has discussed, sometimes these tools may not be able to capture high degrees of heterogeneity or the underpinning geochemical processes in a particular area. So we were really interested in looking more in depth at groundwater quality in Central and Southern Myanmar to see if we could disentangle some of this information further.

SLIDE 8

So this next section is going to be a summary of a paper that we published in 2020 called Major and Trace Including Arsenic Groundwater Chemistry in Central and Southern Myanmar. The scientific publication is open access which means that anyone can can access it freely and share the content from within. This is a collective effort from a number of different collaborators both from The University of Manchester and from overseas partners in Myanmar.

SLIDE 9

So the aim of this study was really to better understand the inorganic chemical groundwater quality and spatial distribution of trace contaminants including arsenic in contrasting zones of Central and Southern Myanmar. The objectives of this study were specifically to assess the occurrence, variations and possible release mechanisms of arsenic in groundwater including in comparison to previous work; to look at the overall chemical water quality based on other inorganic parameters, as well as to identify the dominant geochemical processes and controls that impact the groundwater geochemistry in the selected regions.

SLIDE 10

We had field sites located in five zones across Myanmar and near the areas of Kalay, Mandalay, Maubin, Thongwa and Loikaw. We collected samples from each of these zones and the site selection was based on identifying areas that had contrasting predicted arsenic hazard as well as contrasting hydrogeological conditions. We also worked in collaboration with local partners to to identify suitable field areas.

SLIDE 11

These are some photos of the sampling and analysis that was undertaken. So the photo on the top left shows sampling from from the typical tube well that's connected to a hand pump, the picture on the bottom left is of a dugwell. And the pictures on the right show some of the field activities that we did. So after samples were collected we ran some particular tests in the field directly and we also prepared samples for for subsequent analysis in labs so we did filtering and sample preservation as as was necessary for those particular samples.

SLIDE 12

To very briefly summarize some results. So we were interested in understanding what the dominant water type was in these different areas. So this is a piper diagram which can be used to visualize the relative abundance of major ions. We found that water type was associated with sampling zone as would be expected. In Loikaw Kalay and Mandalay the groundwater was dominated by calcium and magnesium bicarbonate types which is typical of shallow fresh groundwater and is also consistent with high arsenic groundwater type in Cambodia. In Thongwa some of the water was a sodium chloride type which is more saline and typical of marine influence. And found in all the different zones was sodium bicarbonate type and this suggests groundwater is influenced by ion exchange in some locations.

SLIDE 13

We were interested in looking at the overall chemical composition. So these are box plots which can be used to visualize the concentrations and distribution of chemicals so the most abundant constituents were bicarbonate, sodium, calcium, chloride and magnesium. In lower concentrations but with a lot of variability were parameters such as sulfate, nitrate, ammonium and potassium. And trace elements which we'll discuss in a little bit more detail had quite a wide variety variability as well as regional differences and we'll discuss arsenic separately as well too.

SLIDE 14

So we wanted to compare results to the World Health Organization guidelines and this is what is called an exceedance plot where your measured concentrations are divided by the guideline value for a particular parameter, and when exceedences are above one that means that that particular sample or that particular parameter is an exceedance of the guideline value. So you can see here that there's a number of samples that are above one indicating that the concentrations of those elements is higher than the guideline value. So you can see that this happened in a number of cases particularly for arsenic, fluoride, nitrate, iron, manganese and ammonium. There are also spatial trends that can be observed for example there tended to be a higher fluoride in Loikaw or higher manganese in Kalay for example. There's not enough time here to cover this in detail but I would like to refer you to the full paper which discusses this with a lot more information.

SLIDE 15

In terms of arsenic we found that arsenic concentrations range from below detection, so less than ~ one microgram per liter to greater than 500 micrograms per liter, with maximum concentrations found in the Ayeyarwady Basin. This is consistent with hazard predictive models in areas of recent alluvial and delta deposits as well as some previous field studies in Myanmar. We interestingly also found some elevated arsenic in other local locations particularly in Loikaw and Kalay which is interesting because these are areas of lower probability than predicted from hazard maps. Overall around 14 % of the samples had arsenic exceeding the guideline value of 10 micrograms per liter and so this is interesting and particularly the areas that had not been identified before as being a high priority zone for arsenic. We did find that there there might be some arsenic in some of those locations as well so this raises some very interesting research questions for the future.

SLIDE 16

We also looked at the distribution of other inorganic parameters so for example fluoride. Some of that was also elevated in Loikaw or in the delta region. Nitrate tended to be mostly elevated in the Mandalay area. Ammonium was mostly elevated in Maubin and Thongwa zones and electrical conductivity particularly was in Thongwa near the coast in addition to in Mandalay and Kalay. So again the full paper provides a lot more details on this but I just wanted to signpost the type of work that we have done.

SLIDE 17

Principal Component Analysis was undertaken to reflect and to understand the main expected geochemical processes. Principal components were selected to reflect these processes namely water rock interactions which is indicated by elevated concentrations for example of magnesium, sulfate, bicarbonate and calcium. The principal component two are parameters are associated with a reductive dissolution of iron and manganese hydroxides, so iron manganese and arsenic. And the principal component three was indicative parameters for saline water mixing and agricultural inputs so sodium chloride nitrate and potassium. This helped us to identify the main processes that were occurring in different parts of Central and Southern Myanmar notably reductive dissolution of iron and magnesium hydroxides especially in the Maubin zone which is also where the higher arsenic groundwater was found. Saline mixing or seawater intrusion was observed in the delta region especially in the Thongwa zone. Carbonate dissolution was observed in Loikaw and other water rock interactions in Kalay and Mandalay.

SLIDE 18

Unlike some studies which have shown quite a clear distribution between depth and arsenic in this case we found no clear systematic relationship between arsenic and depth. We did find that the highest concentrations occurred around 20 or 30 meters in depth however there's there are also elevated concentrations found at different depths as well. We did find that arsenic correlates broadly with with iron in the positive direction and is inversely correlated with sulfate and these trends are consistent with the mechanism of reductive dissolution of iron hydroxides and is characteristic of of other arsenic impacted groundwaters in South and Southeast Asia.

SLIDE 20

So just to conclude this is really just to provide an overview of a cross-country groundwater survey that was undertaken in several contrasting and previously underrepresented regions of Central and Southern Myanmar. We identified elevated concentrations of arsenic, fluoride, nitrate, iron, manganese and ammonium as well as salinity in some cases. Approximately 14 percent of the samples that we collected exceeded the world health provisional guideline for arsenic especially in the Ayeyarwady Basin although there were some also elevated concentrations found in Loikaw and Kalay. The main geochemical processes were identified in each of the zones studied and this information is really important and and useful in

understanding baseline water quality as well as for informing future monitoring efforts or future remediation efforts if needed. And again the full paper provides much more detail on this but this was really just to provide an overview of some of the work that has been done recently.

SLIDE 22

Here are some of the references that have been used in this presentation and particularly the the one highlighted in bold is the is the paper that's been the subject of this presentation so i'd refer you to that for further information.

SLIDE 23

And lastly please to to note the disclaimer in terms of of use of this presentation. Thank you very much and we hope you found that this mini lecture was interesting.