PERCHED PLASTIC AQUIFERS

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Introduction

Many countries across Asia and Africa struggle with extreme seasonal water shortage, while in the same year experience monsoon flooding. The limited surface water supplies that are available are increasingly polluted from the country's industrial growth. A method of optimising monsoon rains and preventing its pollution could change millions of lives around the world.

Throughout this essay Beijing Province, China is used as an example of a region that has heavy monsoon seasons and a large industrial city as a source of plastic waste and pollution [1].

Construction & Geology

In areas of short, heavy monsoon seasons, a huge amount of the annual precipitation is lost in run-off. The geology of these areas means that water either runs off the surface or percolates down through the ground until it meets the bedrock and is quickly moved on in an outflow of the water table. The idea of perched plastic aquifers is based on natural perched aquifers where an underground water source is located above the main water table by a curved impermeable layer preventing outflow [2]. The proposed aquifer is a construction similar to a small landfill site, lined by a composite of waste plastic and clay. The body of the aquifer would be a saturated soil allowing a community to pump water from it via shallow boreholes all year round as shown in figure 1.

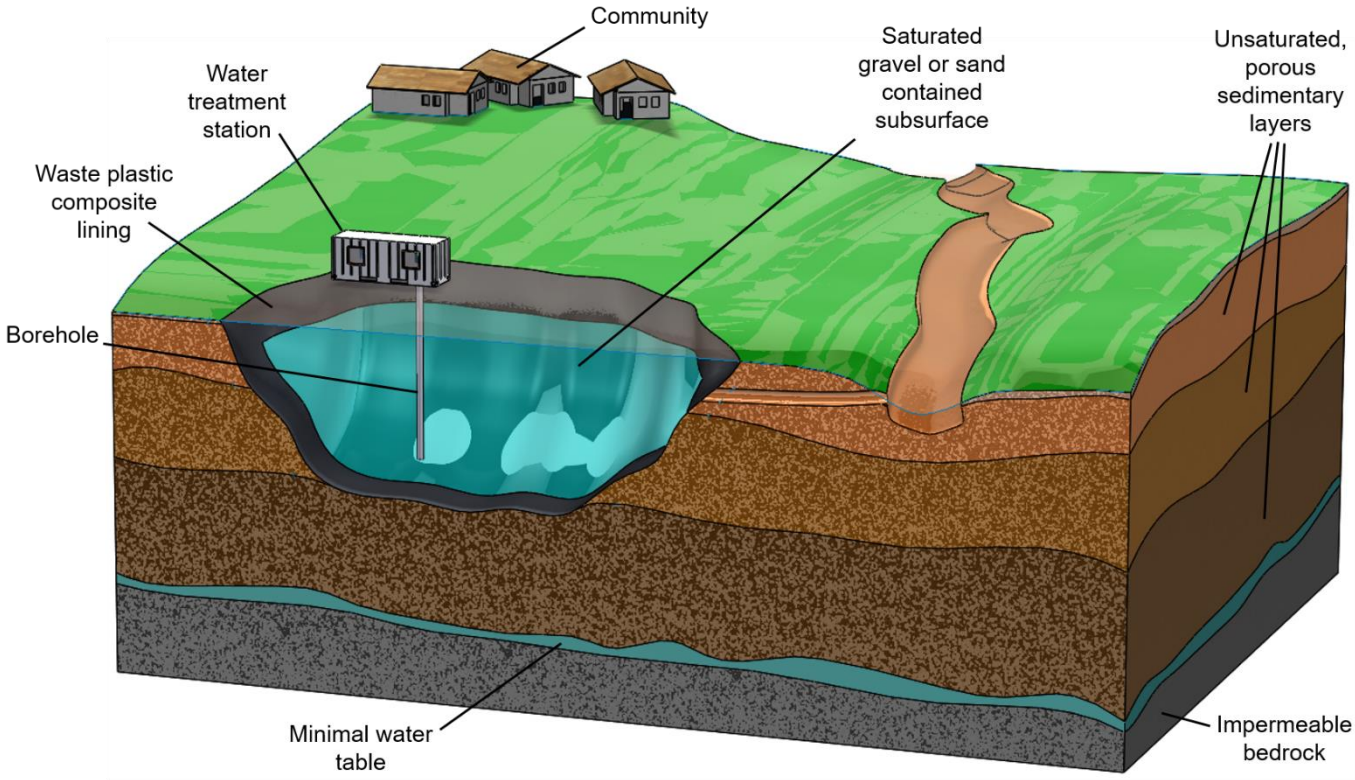

Figure 1: Dry season- showing the aquifer construction and water retention during dry season.

The purpose of using waste plastic, an abundant resource in developing countries, is to utilise its low permeability to store water instead of diverting it. Clays removed from the site would be mixed with the plastic to form a cohesive composite preventing the plastic from dispersing. The disturbance of waste plastic to groundwater systems was noticed in one of the studies for India's immensely successful waste plastic road construction projects where it reads '*Waste plastic materials interrupt the infiltration and percolation of rain water through soil pores and in turn diminishes the ground water recharge in aquifers'* [3]. The inclusion of the waste plastic in these developments promotes the collection of waste and allows it to become a solution, and not a contributor, to groundwater shortage.

The ability to position these aquifers enables them to be developed close to a community in need and positioned somewhere that allows them to be recharged most effectively during monsoon season; for example, next to an ephemeral river (figure 2). Once constructed, the only maintenance of these aquifers would be preventing the surface from becoming clogged by puncturing the ground. Educating communities in how to preserve their sites would be key to a sense of local ownership and, in turn, the aquifer's longevity.

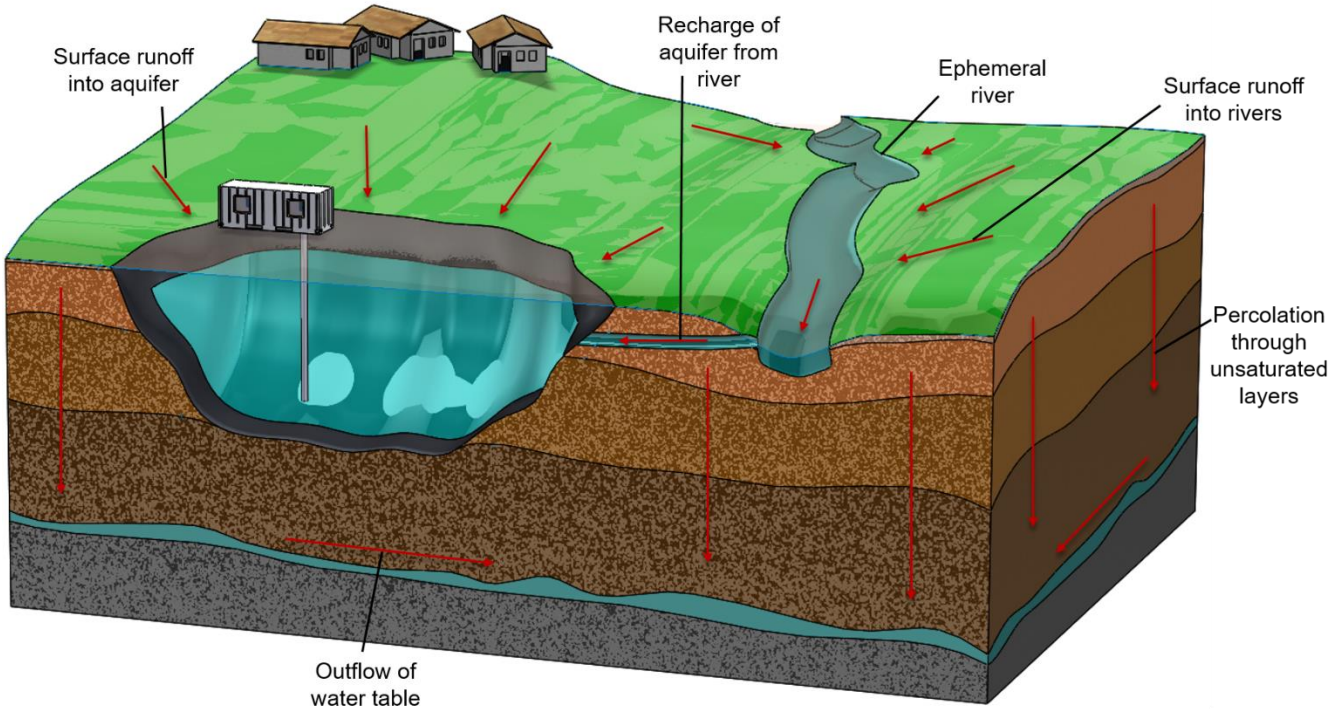

Figure 2: Monsoon season- showing the movement of rainwater (in red) and how the aquifer would be recharged.

Capacity and Distribution

The aquifer capacity required to support an average rural town is calculated in the following equations. The calculations are based on using twice the basic daily water needs for sanitation (40L/day) and the annual rainfall for Beijing Province (577mm) [4,5].

$$Yearly\ water\ volume = Population \times Yearly\ usage\ pp = 10{,}000 \times 40 \times 365 = 146 \times 10^6\ L$$

$$Recharge\ catchment\ area\ = \frac{Yearly\ water\ volume}{Yearly\ rainfall} = \frac{146 \times 10^6}{577}\ =\ 0.25 km^2$$

$$Aquifer\ volume\ = \frac{Yearly\ water\ volume}{Porosity\ of\ Aridosol\ [6]} = \frac{146 \times 10^6}{0.5} = 292000\ m^3$$

These idealised calculations show that:

- The catchment area recharge is insignificant, especially when supplied by a river.
- The volume of aquifer required to support a typical rural town is significantly within the capacity (and therefore construction capability) of small landfill sites.

In the regions surrounding large cities, large-scale landfill developments could be replaced by a number of aquifer developments. Machinery and labour would be outsourced from the cities to support the construction of the aquifers across the province.

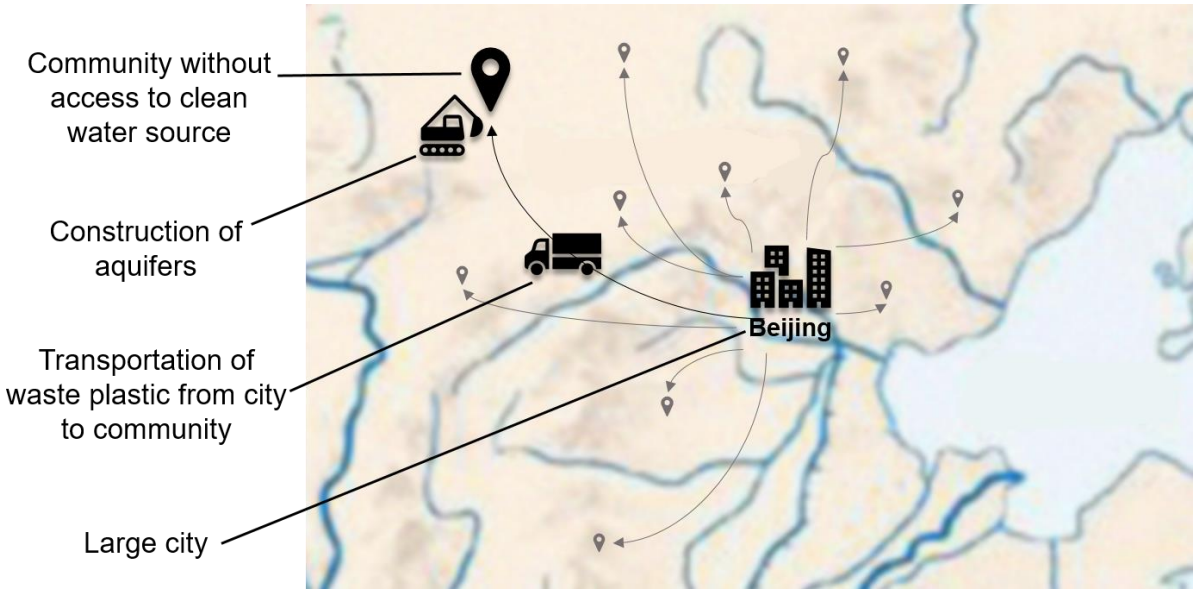

Figure 3: Distribution map showing how a city would divide its waste to support multiple aquifers [7].

Water Quality

Access to high quality water is a huge challenge in areas of high pollution, as surface water is often contaminated with heavy metals from both domestic and industrial waste [8,11]. Across northern China villages are being 'killed' by their water [9] and 19% of main rivers are too polluted even for agricultural use [10]. The aquifer benefits from being underground and largely sealed off from these external sources of contamination. The use of plastic as the impermeable layer does however introduce plastic fibre contamination. The size of these fibres dictates the process required to remove them. For example, microplastic fibres are present in drinking water across the world and despite ongoing research, it has not been linked to any health risks [12].

A bespoke treatment station that meets the specific needs of the aquifer would need to be developed. Researchers at the University of Melbourne have claimed to have developed a cost-effective filtration system of 5 barriers that is able to turn waste water into drinking water [13]. This is a shipping container sized solution that is already designed for transportation to remote areas. Refinement of the barriers to treat plastic fibres would be necessary but this may be desirable over the challenge of treating more toxic pollutants found in surface water.

Conclusion

This novel method of optimising monsoon rains is applicable to a huge number of communities worldwide. With higher water quality and retention than surface water solutions, the principal may be possible to apply to agriculture and industry too.

The ability to apply this solution to almost any location, using appropriate technologies, enables it to target areas where there is currently no water for most of the year. In the absence of any clean water otherwise, this solution is infinitely better than the current situation.

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Appendix 1 - Glossary of Terms

- Perched water table - A perched water table is an accumulation of groundwater that is above the water table in the unsaturated zone. The groundwater is usually trapped above an impermeable soil layer, such as clay, and forms a lens of saturated material in the unsaturated zone.

- Ephemeral River - An ephemeral waterbody is a wetland, spring, stream, river, pond or lake that only exists for a short period following precipitation, for example in monsoon season.

- Borehole - A deep, narrow hole made in the ground, especially to locate water or oil.

- Porosity - The ratio of the volume of interstices of a material to the volume of its mass

- Aridosols – A class of sandy soil that is found in Northeast China.