Professional suggestion to alleviate the water shortage problem of Mekelle city

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Mekelle city and Aynalem well-field are totally located in limestone (calcium-carbonate - CaCO₃) terrain. Calcium-carbonate by nature is soluble in acidic water. Above all, Mekelle city and its surrounding area are highly affected by tectonics (deep fracture systems) of Afar (Ethiopian) rift-valley. West-east, North-south, Northwest–southeast trending faults and fracture systems are prominent in Aynalem and Mekelle area.

The scientific fact and factors playing role in Mekelle area water shortage will be discussed as follows. Regarding the water disappearance in deep boreholes drilled around Aynalem (Mekelle water supply site), the percolation of rainwater (acidic in nature) through extensive and deep fracture systems in soluble limestone terrain of Mekelle is creating big underground passages along fracture zones, by the chemical process called dissolution. The limestone is readily dissolved away along joints or other openings allowing water to escape down hundreds of kilometers deep in underground and making it unavailable for domestic use, even through drilling. Dissolution, also called chemical solution, is the process of chemical weathering of bedrock in which the combination of water and acid slowly removes mineral compounds from solid bedrock (limestone in this case) and carries them away in liquid solution in underground.

The carbonic acid (that causes these problems) is formed as rain passes through atmosphere picking up carbon dioxide (CO₂), which dissolves in water. Once the rain
reaches the ground, it may pass through soil that can provide much more CO₂ to form a weak carbonic acid solution, which dissolves calcium carbonate while passing the fractured limestone beneath the surface of the earth, eventually forming underground passages along fracture lines.

The primary reaction sequence in limestone dissolution is the following:

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\begin{align*}
H₂O + CO₂ &\rightarrow H₂CO₃ \\
CaCO₃ &\rightarrow Ca^{2+} + CO₃^{2-} \\
CO₃^{2-} + H₂CO₃ &\rightarrow 2 HCO₃^- \\
CaCO₃ + H₂CO₃ &\rightarrow Ca^{2+} + 2 HCO₃^- \\
\end{align*}
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N.B. Water in Mekelle is very hard to drink because it has the following ionic components: Ca²⁺ and HCO₃⁻. These ions, particularly calcium cation make the water difficult to drink.

This phenomenon seeps the percolated water (groundwater) deep in the permeable strata (thick limestone strata) in thousands of kilometers down around Mekelle and makes water unavailable for drinking or other domestic purposes. Rainwater seeps downward through the soil and through fractures in the rock responding to the force of gravity. The carbonic acid in the moving ground water dissolves limestone (subsurface strata) along the surfaces of joints and fractures as I already mentioned above. It is natural process and it is difficult to alleviate it. Water may not be obtained even though drilled several kilometers down because of the above chemical aspects. This is the nature of limestone terrain all over the world.

The only water being pumped from the deep boreholes in Aynalem, Mekelle area is from extensive horizontal perched aquifer, located deep underground. It is deceiving clay layer intercalated in limestone, and located deep in underground. It is semi-permeable layer that holds water up that percolates deep underground via fracture systems. It is called deceiving aquifer because it holds water temporarily up and yields low amount of groundwater for domestic use. When more water is pumped continuously, then it seems dried but still yields certain amount (discharge) with prolonged time period. This is because, water from recharge on the way down via deep fracture systems is getting trapped as semi-permeable clay layer prevents its direct passage down and then get caught by deep boreholes. However, this can never be sustainable solution for the ever growing population of Mekelle city. And it is not reliable indeed.
The number of population is growing faster every year in the city while the water problem still remains unsolved. For that reason, other alternatives must be in place to solve the problem permanently. The following will be the suggested solution. Drilling deep boreholes in basaltic terrain of Raya valley nearing the well-field, integrating with spring water of that area and sending towards Aynalem site by gravity method will be best alternative solution for this problem. Groundwater and spring water from basaltic terrain can be accumulated in big tanker on the mountainous area of Raya Valley that has higher elevation than Mekelle city (particularly Aynalem well-field). Then, water can be transported by gravity method until Aynalem and from there; it can easily distributed to whole city of Mekelle and its surroundings. It is simple methodology to implement. There are no or very little other alternatives in place that anyone can take so that Mekelle city can have sustainable water supply for ever growing population. Even though it is far, it must be done. Above all the water will be soft and very comfortable to drink.

The current yield of the boreholes at Aynalem well-field and the methodology that I suggested here above will permanently alleviate the water problem of Mekelle city to best of my knowledge.

Thank you.

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