An approach to tackling fluoride problem in drinking water

Several parts of the country, especially of Gujarat State, have high levels of fluoride (5–40 ppm as against the acceptable limit of 1.5 ppm) in the available drinking water. This gives rise to fluorosis, a disease that affects bones, teeth, etc. The conventional approach is to provide defluoridized water for domestic use employing chemical precipitation of fluoride ions. This approach has, however, not met with much success as defluoridization systems require a high level of technical backup for operation and maintenance. We, therefore, need to look for long-term effective solutions to ameliorate the problem. In this note we present a simple approach employing basic hydrological principles that can provide fluoride-free drinking water in most parts of the country. In addition to tackling the fluoride problem, this approach will result in developing an additional water source, making each village unit self-sufficient for its most vital need of water.

At the outset, it must be realized that the fluoride problem in most parts is of recent origin. It is essentially related to the declining of ground water levels due to over-exploitation, mainly for irrigation, resulting in virtual drying up of the shallow unconfined aquifer. This has led to exploitation of deeper aquifers containing high levels of fluoride. Therefore, a long-term solution to the fluoride problem in drinking water must involve a strategy that makes use of the rain water (which is essentially fluoride-free). This can be done through reviving of the shallow ground water sources through harvesting of rain water and its recharge into the unconfined aquifer.

Harvesting of large amounts of rain water and its recharge into underground aquifers, however, poses some practical problems related largely to the hydrometeorological conditions prevailing in our country. Most of the rainfall over India occurs in a short rainy season of about 3 months in 4–5 concentrated spells of 3–4 days duration each. The average rainfall intensity is 3–4 cm/day and on occasions as high as 15–20 cm/day. This results in large runoff volumes and low infiltration rates in the natural course. It is also important to note that potential evaporation in most parts of the country is in excess of 250 cm/year. Therefore, our strategy should be (i) to provide holding of as much water as possible and for as long as possible in surface and underground reservoirs and (ii) to accelerate the rate of ground water recharge through artificial means. We, therefore, suggest developing exclusive ponds/tanks artificially (if not already existing in the vicinity of the village) to store a substantial fraction of rainfall runoff. This should be combined with specially designed percolation wells to effect recharging of shallow unconfined aquifers. The surface storage enables holding of large part of runoff for a time sufficient to effect its recharge into the shallow unconfined aquifer through percolation wells.

A percolation well is nothing new but the well-known soak pit with its top covered and the bottom opening into a shallow-level permeable stratum having little or no water. The water coming into the well will dissipate into the permeable formation (aquifer) through percolation/infiltration from the large surface area of the aquifer that the well intercepts. Since the storm water is laden with considerable amount of suspended silt/sand, an appropriate silt trap is required at the entrance of the percolation well. In the present case the tank itself will serve as a silt trap. As percolation wells intercept large surface area of the permeable formation, very high recharge rates can be achieved. This has indeed been demonstrated in a percolation well constructed in the basement of a shopping complex in Maninagar, Ahmedabad, during the monsoon of 1994. In this experiment the entire runoff during a heavy spell (13 cm in 24 h) from the 1800 sq yd (1504 m^2) paved catchment area of the shopping complex was diverted into the percolation well of 12 ft (3.66 m) diameter and 30 ft (9.14 m) depth. This dissipated into the surrounding permeable medium sand formation within about 96 h.

Even if the shallow aquifer is dry to begin with, a local ground water mound develops as a result of the infiltration of water from the tank and the percolation well. Fluoride-free safe water can now be abstracted from this ground water mound. This can be done through a shallow tubewell in the vicinity of the percolation well (10–15 m away) tapping layers that are at least 10–15 m below the bottom of the percolation well. Since this water would have travelled about 10–15 m through the aquifer, it is expected to be free of any pathogens that may have been present in the source water from the tank. It is, therefore, essential to keep the catchment area of the tank as free as possible from such human activities as may tend to pollute the water in the tank. One should also ensure through appropriate measures that the recharged water remains available for drinking purpose and is not consumed for irrigation and other uses.

In summary, our strategy involves: (i) conservation of rain water through short-term surface storage (3–4 months); (ii) long-term aquifer storage; and (iii) purification through traversal within the aquifer. This can provide an annually renewable fluoride-free drinking water source in most regions of the country. Since drinking water needs in terms of volume are small but require a high-purity source, we believe that the simple strategy outlined above will make each village self-sufficient in this regard.

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