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Fluoride Incidence in Groundwater: An Insight from Rural Parts of Central India

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Fluoride (F^-) is one of the chemical elements necessary for human life. Deficiency or excess of F^- in the environment is closely associated with human health. The problem of high concentration of F^- in groundwater sources has now become one of the most important toxicological and geo-environmental issues in developing countries including India. Excessive F^- ingestion (above 1.0 mg/l) through drinking water is the prime causative factor in the development of fluorosis.

Hydrogeological investigations have been carried out in rural parts of Yavatmal district Maharashtra where agriculture is the main occupation and majority of the population is farm labourers and tribals.
The present area is mainly occupied by basaltic lava flows of Deccan Volcanic Province except in the southern part where limestone and shale belonging Penganga Group and Quaternary Alluvium occur. The Deccan lava flows are both aa and compound pahoehoe types and are mostly dark grey, fine to medium grained, massive to vesicular and non to moderately porphyritic. Petrologically, basalts are mainly composed of plagioclase and pyroxenes with small amount of amphiboles and biotite with secondary fluorite veins. Groundwater occurs under unconfined conditions in the weathered and fractured portions of rocks and semi-confined to confined conditions in fractured rocks. Groundwater samples from shallow and deeper aquifers situated in close proximity with each other were collected for comparative study. F^- concentration along with other chemical parameters were analysed using the standard chemical analytical techniques.

Groundwater in the present area is of bicarbonate type with neutral to moderately alkaline nature in shallow aquifers (depth less than 20 m) and moderately alkaline to alkaline nature in deeper aquifers (depth more than 40 m). The comparison of F^- concentration of groundwater from the shallow (open wells) and deeper aquifers (bore wells) from the same location has indicated that the deeper aquifers have higher concentration of F^- than the shallow aquifers. Similarly, the pH of groundwater from deeper aquifers is high compared to shallow aquifers, and increases along with F^-. The F^- concentration varies from 0.2 to 4.96 mg/l in open wells and between 0. 1 to 16.62 mg/l in bore wells [1, 2]. The source of F^- in the groundwater of the area appears to be fluorite and hydroxyl minerals. In the present area bore wells tapping compound 'pahoehoe' flows have higher concentration of F^- as compared to open wells tapping simple 'aa' flows. Comparative sluggish movement of groundwater in compound 'pahoehoe' flows provided more favourable hydrogeological conditions for dissolution of F^- as these are more porous and less permeable, which in turn provided more time for leaching of F^- bearing minerals under alkaline environment. The rock–water interaction is the main process for the source of F^- in the groundwaters of study area, in which F^--rich minerals are decomposed / dissociated from the source rock and F^- is dissolved in the groundwater by dissolution. High concentration of F^- in deeper aquifers compared to shallow aquifers could be due to its high residence time in the aquifer system, thereby having longer contact time for dissolution of F^--bearing minerals present. The influence of local lithology, aided by factors like semi-arid climate of the region may be responsible for higher concentration of F^- in

the groundwater of the region. We suggest that the drinking water source from the affected area may be met from surface water or from open wells. Artificial recharge structures may be constructed to augment available storage potential of the shallow aquifers of the area. Health related studies shall be taken up and villagers shall be educated about the hazards of consumption of F^- bearing water and use of simple methods of defluoridation.

References:

[1] Madhnure Pandith et al. (2007) Curr Sci 92(5): 675-679

[2] Madhnure Pandith et al. (2016) Environ Monit Assess, DOI 10.1007/s10661-015-5027-z