IDENTIFICATION OF POLLUTION SOURCES IN GROUNDWATER

In the rising complexities of supply and demand of water coupled with requirement of quality assurance, the pressure on groundwater has increased with the passage of time. Some of the definite reasons are: (i) groundwater is considered to be assured, and more risk-free to pollution than surface sources of water, (ii) unsaturated zone filters the percolating water before it becomes a part of groundwater aquifer, and (iii) soil pores of saturated zone also play the role of filtration etc. However, the disadvantages with the groundwater aquifer are: (i) difficulties in decontamination if it is contaminated, (ii) increasing human activities and their by-products (changing land-uses and land cover) not only promote threat to the hydro-geological conditions of an aquifer but also exaggerate spreading of toxic elements present in-situ in the groundwater domain. Some of the recently reported natural calamities in groundwater aquifer (Arsenic pollution, Fluoride activation etc.) in some parts of the country are cited as examples.

Prevention and cure of a disease is possible when the disease and its source are known. As decontamination of groundwater is a difficult task, or requires a gigantic cost involvement if a remedial plan is initiated, an accurate, reliable and cost effective method is essentially required to identify the source of contamination of water in an aquifer.

TECHNOLOGY

A source of groundwater pollution is said to be a known source when it is apparently visible or can be detected with certainty. A source of pollution originating from surface and leaching vertically downward to an aquifer can easily be detected. However, it is difficult to detect a hidden source (not apparently visible), which is triggered off because of exploitation of groundwater. Migration of pollutants from a polluting stream/river by the process of stream-aquifer interaction, activation and oxidation of in-situ toxic compounds due to the change of hydro-geological conditions etc. are some examples of hidden sources of groundwater pollution (as shown in Figure-1). For planning and developing an appropriate remedial measure the specific question before a planner and a decision-maker is; how can one detect a subsurface source, and what is its zone of influence? What are the cost-effective remedies? Definitely the answers would be scientific analysis.

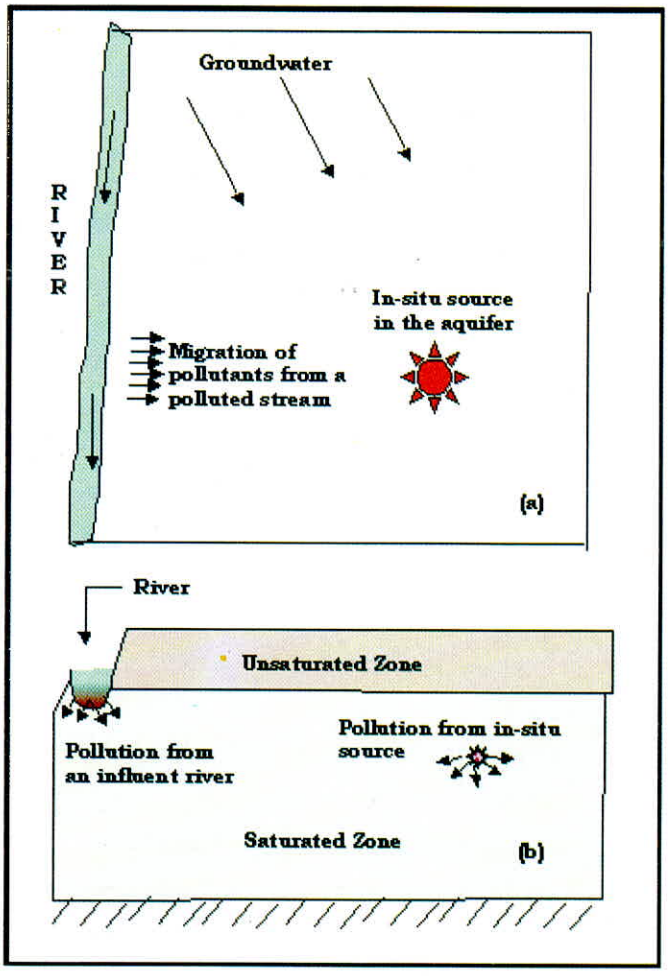

Figure – 1 Unknown sources of pollution in a groundwater domain (a) plan view (b) cross-sectional view

The groundwater flow velocity, hydrodynamic dispersion, sorption and kinetics of the organic matters, besides other factors, are primarily responsible for propagation and spreading of pollution source in a groundwater domain. Influence and dominance of these factors depend upon stress conditions (recharge and withdrawal rate), degree of heterogeneity of the aquifer material, nature of pollutants, soil types and soil textures etc. The larger the rates of recharge to ground water or the larger the withdrawal from groundwater, the more is the spreading of pollution in a groundwater domain. When pollutants are in dissolved form, they become part of the groundwater domain and move with the flow of groundwater.

In groundwater domain, pollutant moves along all three directions of flow, i.e. major flow direction, transverse direction and vertical direction. Pollutant's transport mechanism in groundwater is well defined by 3-dimensional mathematical equation known as Advection-Diffusion equation. Numerical solutions to this equation for different real-life flow conditions of pollutant transport are well documented in books. There are a number of source codes (models) available internationally derived using the above transport equation. Computational ease and scope of those models coupled with one's modeling skill have made identification of migration pathways of pollutant in a groundwater domain easy with good accuracy and certainty.

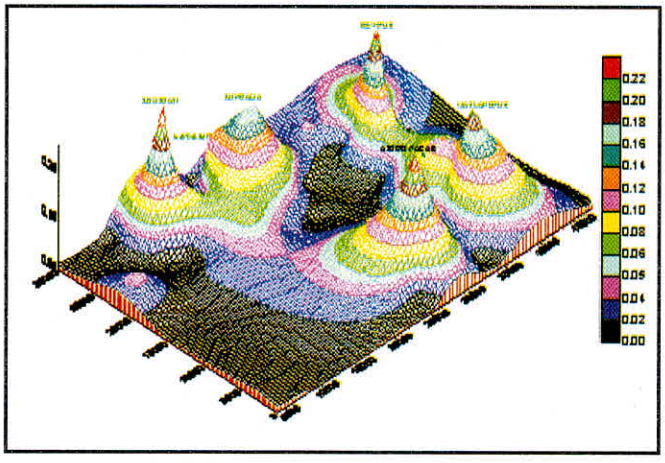

Figure – 2 Arsenic contaminated zones (> 0.05 mg/l) in groundwater domain in a arsenic affected area in West Bengal

For identification of source of pollutant in a groundwater domain, a modeler has to develop an artificial domain of the prevailing hydrological and hydro-geological set up of the aquifer whose mathematical characteristics are representative of the physical processes of the actual aquifer through which pollutants move. Thereafter, simple tracking of particle movement in a flowing media from known to unknown source or unknown to known source is done.

A primary requisite for tracking of movement of a particle in a groundwater domain is to know flow velocity along three flow directions. The flow velocity changes due to the heterogeneity of the aquifer as well as the variation of stress conditions. Measurements of spatial and temporal variation of flow velocities are not only tedious but also a difficult task. Groundwater flow modeling is, thus, a prerequisite for pollution source identification and evolving a remedial strategy or for developing a well-head protection strategy or for delineating a risk-free zone.

Expertise available at the National Institute of Hydrology, Roorkee on pollutant transport modeling and associated areas has successfully been utilized for study of arsenic pollution in groundwater in a selected patch of West Bengal in joint collaboration with Central Ground Water Board (CGWB).

ENVIRONMENTAL IMPACT

The methodology does not deal with any artificial injection of pollutants or implementation of a scheme but a tool for analysis and identification of source in a groundwater domain already under the threat of pollution. Hence, there is no adverse impact on the environment.

ECONOMICS

Groundwater is the main source of water for different uses, including drinking, in many regions in the country. Safeguarding groundwater sources from any pollution hazards should be everybody's concern. The proposed package of scientific tools and analyses, if implemented, will bring out a direct benefit to the socio-economic and socio-cultural aspects of a region.

BENEFICIARIES

Central and State Ground Water Organisations, Pollution Control Boards and users of any scheme based on groundwater.

INTELLECTUAL PROPERTY RIGHTS

No element of Intellectual Property Rights is involved in the use of this technique.