Impact of groundwater contamination on human health

D. Karunanidhi · T. Subramani · Priyadarsi D. Roy · Hui Li

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Background

Groundwater pollution is a worldwide problem with significant effects on human health and environmental security. It requires an in-depth understanding as the access to safe drinking water is a fundamental human right. The inferior quality of potable water has been deteriorating the human health and affecting the sustainable development of society. Increased urbanization and population growth in many parts of the world have exacerbated contamination of groundwater, mainly through the misuse of groundwater assets and the discharge of domestic and industrial sewage into the groundwater system. Human health is susceptible to the exposure of metal/metalloid, even at

trace level, because of its persistence in the environmental media and acute toxicity.

This special issue “Impact of Groundwater Contamination on Human Health” is a compilation of new case studies about recent advances in ground-breaking research about groundwater characteristics and groundwater modelling in different parts of the world using multidisciplinary tools to evaluate the risk on human health as well as on agricultural activities from chemical compositions and radioactivity along with other cutting edge topics like waste water management as well as microbial and heavy metal contaminations. It contains 23 different research papers from five countries (China, India, Kazakhstan, Kuwait, and Malaysia) focussing on seven different topics: (1) Hydrogeochemistry, (2) Groundwater modelling, (3) Risk assessment, (4) Radioactivity, (5) Wastewater treatment, (6) Heavy metals contamination, and (7) Microbial contamination. This editorial briefly reviewed the papers that focussed on different topics of groundwater evaluation and characterization.

D. Karunanidhi (✉)

Department of Civil Engineering, Sri Shakthi Institute of Engineering and Technology (Autonomous),
Coimbatore 641062, India
e-mail: karunasamygis@gmail.com

T. Subramani

Department of Geology, College of Engineering Guindy
(CEG), Anna University, Chennai 600025, India

P. D. Roy

Instituto de Geología, Universidad Nacional Autónoma de México (UNAM), Ciudad Universitaria,
04510 Ciudad de México, C.P, Mexico

H. Li

Department of Ecology, College of Life Science and Technology, Jinan University, Guangzhou, China

Hydrogeochemistry

Six papers of this topic represent case studies of saline water intrusion along the coastal Tamil Nadu and Puducherry states of south India using hydro-chemical and statistical techniques. Faizal Khan et al. (2020) reported about the mixing of seawater and

groundwater in majority of the samples along the coastal south India. This study recommended implementation of proper awareness programs along with regular monitoring, regulated pumping from wells situated close to the coast and better agricultural practises in future. Satheeskumar et al. (2020) observed that more than 40% of samples in the Thamirabarani delta of south India are unsuitable for drinking, and their higher electrical conductivity (EC) and total dissolved solids (TDSs) values reflected the seawater intrusion, in addition to the anthropogenic activities (salt panning). Vinnarasi et al. (2020) assessed chemical weathering and atmospheric carbon dioxide (CO₂) in Shanmuganadhi River basin of south India in order to evaluate the groundwater quality management for decision-making.

Keesari and Dauji (2020) investigated groundwater salinization using correlation plots of Na + /Cl- versus Cl-. This study used qualitative and quantitative tools from published datasets. Marghade et al. (2019), however, used geochemical and multivariate statistical approaches to investigate groundwater quality and human health risk in a semi-arid region of Maharashtra state in western India. This study revealed water–rock interactions, de-dolomitization and reverse ion exchange as the main controlling processes. The health risks assessment from consumption of F-polluted groundwater showed more risk for children (40%) compared to adults (23%). The study also recommended rainwater harvesting for improving the groundwater quality as well as sustainable development and management of groundwater resources. The paper of Zhou et al. (2020) assessed the suitability of groundwater quality for irrigation and health risk in a part of north China and suggested that the deep groundwater is of better quality compared to shallow groundwater. Health risk evaluation indicated non-carcinogenic risk from F⁻, Fe and As. Regarding the deep groundwater, Cr⁶⁺ might contribute to non-negligible non-carcinogenic risk for children.

Groundwater modelling

Three articles refer to this topic and the paper of Arya et al. (2019) evaluated health risk from rural drinking water supply by using inverse mass balance modelling (NETPATH code) in Vattamalaikarai River basin of south India. The calculated HQ values highlighted

more risk for children and suggested effective remedial measures such as construction of artificial recharge structures to reduce the excess fluoride. Karunanidhi et al. (2020a, b) described subsurface hydrogeochemical processes in a geologically heterogeneous semi-arid region of south India using mass transfer and fuzzy comprehensive modelling, and reported high influence of silicate weathering, ion exchange and gypsum dissolution on overall quality of the groundwater. Similarly, Radelyuk et al. (2020) assessed groundwater safety close to contaminated water storage sites in Kazakhstan using multivariate statistical analysis and Heckman selection model (a very first attempt to evaluate environmental factors) and confirmed a high loading of anthropogenic contamination from the petrochemical industry coupled with natural geochemical processes.

Risk assessment

Out of the seven papers of this topic, Ahmed et al. (2020) evaluated the high carcinogenic and non-carcinogenic risk from arsenic (As) in drinking water in Langat River Basin of Malaysia. Even though the major source of As is changing landscape, examining ponds and extensive use of pesticides for palm oil plantation, this paper mentioned no potential non-carcinogenic health risk since the calculated hazard quotient (HQ) value was < 1. He et al. (2020) discussed about the poor water quality in Datong Basin of northern China from high levels of arsenic (As), fluoride (F⁻), and iodine (I). The long-term intake of this groundwater has led to endemic arsenicosis and fluorosis. This article recommended consumption of regular salt, and the conjunctive use of groundwater and surface water in the basin and mountainous areas as one of keys to sustainable health and groundwater management. In the Ordos Basin of China, Ding et al. (2020) assessed the agricultural and domestic challenges by focussing on the groundwater quality. The water quality of most samples is poor for consumption and 80% of the water, however, can be used for irrigation. Similarly, the children are exposed to higher risk compared to adults. Li et al. (2019) conducted an assessment of potential health risk of major contaminants in groundwater of Hebei Province in central China and reported non-carcinogenic risk values (Rn) in the order infants > children > adult

males > adult females and the sequence of the carcinogenic risk values (R_c) in the order adult males > adult females > children > infants.

Karunanidhi et al. (2020a) also discussed about drinking water quality and possible health risks in the Shanmuganadhi River Basin of south India. The water quality index (WQI) revealed that 52% of samples are in poor, very poor and not suitable categories, causing more health risk for children. In a study of south-western Punjab (India), Kumar et al. (2020) described the source, distribution and potential health risk assessment. Elevated levels of U and F from the geogenic origin, along with the minor anthropogenic activities, are the major health risk pollutants. The carcinogenic health risk of As and Cr exceeded the USEPA limits (10^{-6}) and this study recommended that the local government should take necessary steps to provide potable water facilities along with awareness camps. Subba Rao (2020) evaluated probabilistic non-carcinogenic risk in a rural dry area of south India with high nitrate (31–97 mg/L) and fluoride (0.70–2.80 mg/L) levels in groundwater. This research suggested adverse health risks among men, women, and children caused by sensitiveness to pollutants, and different body weights.

Radioactivity

Only one paper of this topic was by Nazir et al. (2020) and it investigated the dose estimation of radioactivity in groundwater from the Srinagar City (north India), using fluorometric and scintillation techniques to measure uranium and radon. The uranium concentration is less than the permissible limit ($30 \mu\text{g/L}^{-1}$), but radon exceed the permissible limits of USEPA (11 Bq L^{-1}) in 32% of the samples. This interesting study found that areas with limestone lithology have a higher radon concentration.

Wastewater treatment

Out of the two paper of this topic, Sathya et al. (2020) investigated the utility of photochemical integrated submerged membrane bioreactor for textile dyeing wastewater treatment in SIPCOT, Perundurai (south India). The results showed that high removal efficiencies were achieved by integrating membrane with

photocatalysis for the removal of various parameters (colour, COD, and TSS). About 78% COD removal could be achieved by using this simple integrated system. Vasu et al. (2019) evaluated the degradation of simulated Direct Orange-S (DO-S) textile effluent by using nonthermal atmospheric pressure plasma jet. The paper suggested that the non-thermal plasma treatment is efficient as it induces the degradation of organic solutions.

Microbial contamination

The research paper of Vasudevan et al. (2020) carried out the evaluation of microbial contamination in shallow groundwater along the coastal Tamil Nadu (south India). It inferred more microbial activity in residential areas, cultivated regions and around the landfill sites due to the leaching of sewage water and fertilizer runoffs. The concentrations of ions and microbes remained above the permissible limits of drinking water, but was suitable for irrigation purpose.

Heavy metals contamination

In this topic, Ali and Chidambaram (2020) addressed the impact of As, Cd, Ni, Pb, and V on common fish varieties (Lobster and Speatty) along the Kuwait Bay. Effluents from oil-based industries, urban sewage, and wastewater drains (land-based effluents) and the redox conditions of the natural environment are identified as the chief sources of trace elements in the fish varieties. This paper suggests that the hazard impact was observed to be greater in female population than that in male. Similarly, Venkatesan et al. (2020) focussed on the chromium concentration in vegetables possibly inherited from the groundwater. This study recommended application of gypsum (calcium sulphate) during ploughing of soil to improve the infiltration capacity of water by enhancing the soil structure and to raise salt-tolerant crops and practice crop rotation. In the water from Xiangxi River, and Three Gorges Reservoir of China, Xiong et al. (2020) studied spatial distribution of Cu, Cd, Ni, and Hg, originated primarily from agriculture, and the distributions of Pb, Zn, and As, originated from transportation and mining. The results of this study provided a reference to

support prioritization and planning for heavy metals pollution control.

Conclusion

The subject of this special issue is of great importance for groundwater research, and the 23 papers covered different aspects of fundamental theoretical and applied research about groundwater contamination and human health in order to fill gaps in the existing knowledge.

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