ABSTRACT

Safe and sustainable water resource availability, mostly sourced to groundwater, is gradually becoming a major concern across the world. One-fifth of the global population still does not have proper access to safe drinking water, with a major portion of that population living in in South Asia. India, the largest of the South Asian countries, only has 2.4% of the world's total land area but accommodates ~20% of Earth's population,. The Indus-Ganges-Brahmaputra (IGB) River basin aquifer, which covers most of northern and eastern India, is the major host of potable surface and groundwater resource of India. The eastern part of this IGB aquifer system, also geologically known as the Bengal basin, is spread across the Indian state of West Bengal and neighboring country of Bangladesh and regarded as one of the most densely populated part of the world. The area is also hydrologically extensively studied because of its well-known, pervasive, geogenic, groundwater arsenic pollution.

The present study constitutes one of the first detailed study of a) inter and intra-annual occurrences, b) natural (e.g. geologic, geomorphic, hydrogeologic etc.) and human (e.g. landuse, livelihood etc.) controls, c) contaminant fate and transport mechanisms and d) associated health risk of hazardous anthropogenic sourced persistent organic pollutants (POPs)_e.g. pesticides, polycyclic aromatic hydrocarbons (PAH) and pharmaceutical antibiotics in surface and groundwater and aquifer sediments across ~21,000 km2 of southern West Bengal, which is also known as Western Bengal basin (WBB, ~50 million population). River water (n = 32) and groundwater (n = 235) were collected from community and public drinking water sources for pesticides(2014-2016), PAH (2015) and antibiotics (2016), across four districts, namely Murshidabad, Nadia, North and South 24 Parganas and the megacity of Kolkata (Calcutta). All groundwater samples were found to have at least one of the 40 detected pesticides [e.g. Atrazine

(0.9 – 3.9 μg/L), Malathion (150.1 – 9330.5 μg/L), their derivatives [e.g. Malaoxon (410.2 – 1420.1 μg/L)]. Atrazine, butachlor and malaoxon were most abundant in more than 90% of the river water samples. 16 PAHs [e.g. Naphthalene (4.9–10.6 μg/L), Phenanthrene (3.3 – 6.6 μg/L)] were detected in groundwater samples. Among 235 groundwater samples, naphthalene was predominant in 79% samples, followed by fluoranthene (26% of the samples) and phenanthrene (3% of the samples). Naphthalene was also found to be the most frequent PAHs found in river water samples (84% of the samples) followed by phenanthrene (29% of the samples) among 32 river water samples. About 90% of groundwater samples contain norfloxacin, penicillin and ciprofloxacin. Ciprofloxacin, penicillin and norfloxacin also showed higher frequency in river water followed by erythromycin, streptomycin and quinolones.

Sediment samples were collected at twenty five locations within the study area at three different depths viz. 0–10, 10–20 and 20–30 cm during 2015. Similar to pesticides in water, most of the sediment samples investigated obtain malathion (56-200 μg/kg), malaoxon (>900 μg/kg). Alachlor, atrazine and lindane were found to be predominant in sediments. Naphthalene was most frequent PAHs in three of the layers (82% of the samples). Top sediment consists of mostly naphthalene (79% of the samples), phenanthrene (36% of the samples) followed by fluoranthene (13 %) and benzo (a) pyrene (9%). The top soil consists of mostly norfloxacin (91%), penicillin (86%), ciprofloxacin (83%), and streptomycin (69%). However, sediments collected from 10–20 cm and 20–30 cm depth indicated high concentration of norfloxacin (89.3% at 10–20 cm depth and 85.5% at 20–30 cm depth) than shallower depths.

Agricultural intensification, industrial and urban growth, and improper handling of the effluents generated from these sectors cause impact on river, groundwater and sediment qualities resulting degradation of drinking water quality. Apart from anthropogenic influences, natural controls like hydrogeological setting e.g. depth to water table, flow paths etc. were identified to be some of the strongest influence, which showed significant impact on POP concentrations in groundwater. High-resolution numerical modeling of the advective transport of the hypothetical contaminant particles in the aquifers, suggest up to ~25 times faster movement of pollutants under irrigation-induced pumping systems, suggesting strong control of hydraulics on spatial distribution of these contaminants. Risk estimation shows ~20 million people of the study area, with 53% urban and 44% rural residents are found to be exposed to drinking these polluted waters. Potential future risk has been detected by back propagation artificial neural network (BP-ANN) with attenuation factor of pesticide (AF) to ascertain different mitigation measurement by policy makers. Therefore, identifications of these yet-unknown contaminations in the public-use water sources provide a new insight in to the deteriorating drinking water quality and health concerns in the area, which, otherwise has already been under lot of stress from the known geogenic contaminants, attributed to the “largest mass poisoning in the human history”. Present study proposes a novel risk based approach in mitigating potential human risk due to exposure of contaminated drinking water resources thereby highlighting their potential solutions to minimize the risk of contamination of both surface and groundwater resources.