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Changes in water quality index of Ganges river at different locations in Allahabad

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ABSTRACT

We have determined the water quality index (WQI) of post-monsoon water samples with an aim to assess changes in Ganges river at various locations in Allahabad stretch including that from the confluence with river Yamuna. Physicochemical parameters such as temperature, pH, electrical conductivity (EC), dissolved oxygen (DO), total dissolved solids (TDS), major cations e.g. Na^+, K^+, Mg^{2+}, Ca^{2+}, major anions e.g. F^-, Cl^-, Br^-, SO_4^{2-}, NO_3^-, PO_4^{2-} and alkalinity were analyzed by standard procedures. The values obtained were compared with the guideline values for drinking water by Bureau of Indian Standard (BIS) and World Health Organization (WHO). From the measured quantities, certain parameters were selected to derive WQI for the variations in water quality of each designated sampling site. Results showed considerable deterioration in quality of water at some of the sites. WQI of Ganges river water at Allahabad ranged from 86.20 to 157.69 which falls in the range of poor quality of water. Pearson's correlation matrix was drawn to find possible interrelations among measured water quality parameters. It is shown that WQI may be a useful tool for assessing water quality and predicting trend of variation in water quality at different locations in the Ganges river.

1. Introduction

Ganges river, the largest river of India, is the major source of drinking water for dwellers in cities, towns and villages in its basin area. The Ganges basin is one of the most heavily populated areas in the world with an average density of 520 persons/Km^2. Present study was aimed to evaluate water quality of the river in Allahabad region including at the confluence of Ganges and Yamuna rivers. People living on the bank of the river, apart from drinking, use its water for industrial, agricultural and other purposes, such as, cattle bathing and cloth washing etc. After the usage, water is generally discharged into the river from industrial, agricultural and sewage systems. According to the report of Central Pollution Control Board (CPCB), the capacity of sewage treatment plants is only 42.8% of the total sewage generation (208.00 MLD) in Allahabad (CPCB, 2009. Besides, run off from the rural settlements, open defecations, dumping of carcasses and disposal of dead bodies also contribute to increasing degree of pollution (Status paper on river on river Ganga, 2009).

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River Yamuna, the largest tributary that meets Ganges at Sangam, is found contaminated with the discharged waste water from drains of national capital, Delhi, Mathura-Vrindavan, Agra and Etawa cities down the flow stream. It was also found that ~70% of the cattle population in the basin area of Yamuna river directly uses flowing water for bathing and washing purposes (World Health Organization, 1996). Frequent use of river water by the civilians increases the possibility of human health hazards. According to WHO, about 80% of all diseases in human populations are caused by drinking water (CPCB, 2006). The water quality determines the suitability of water usage for various purposes (Ahipathy and Puttaiah, 2006). Both natural as well as effluent discharges with the toxic compounds due to anthropogenic activities cause problems to communities in the receiving aquatic system and a potential effect on the human health (Duruibe et al., 2007). In view of this, evaluations of quality of river water with respect to location along the stretch and in different weather conditions seem vital to prevent the population sufferings from diseases and ill health.

It is known from reported studies that Water Quality Indices serves a useful indicator of water quality as proposed by Horton (1965). Subsequently, WQI of many rivers of world have been reported including that of many rivers from India e.g. Cauvery river, Tamilnadu (Kalavathy et al., 2011); Mahanadi and Atharabanki river, Paradip area (Samantray et al., 2009); Ramganga river, U.P. (Alam and Pathak, 2010); Ganges river, Haridwar (Joshi et al., 2009) and Rishikesh (Chauhan and Singh, 2010); Subarnarekha at Singhbhum (Parmar and Parmar, 2010). These studies were based on a general hypothesis that the water quality might change because of different intervening human activities, large demographic and urbanization demands at different locations. Because of central importance of Allahabad for public health along the flow of Ganges and its confluence with Yamuna, it was considered relevant and necessary to obtain data on water quality parameters at various sub-regional sites along Ganges in Allahabad including Sangam place and at pre-confluence Yamuna river.

Present study has determined the WQI values from measured parameters of the river water sampled from various designated locations in Allahabad region. WQI values provide a remarkable indicator of quality of water for human and cattle usage and consumption. The rationale of present study is based on the fact that measurement and analysis of some of the selected parameters may collectively yield a fairly good indication for the overall quality of water (Cade, 2001) and also allows us to infer the quality of bulk water (Zhenghui et al., 2012). Computation of Pearson correlation in present study was to find the possible relations between water quality parameters. We were driven by public health concerns to develop WQI of water along Ganges river which presumably would help in planning and implementation of pollution prevention policies in most inhabited and polluted locations (Singhal, 2012).

2. Material and methods

2.1. Sample collection locations

Samples were collected during post monsoon period in December 2011. The post-monsoon months are from October to January of each year. It was decided to select eight designated sampling locations which include 6 sites on Ganges before confluence, namely, Ramchaura Ghat, Neeva, Rasoolabad (Rasulabad), Daraganj, prior to Sangam, confluence named Sangam, pre confluence river Yamuna at Boat Club and beyond Sangam (Table 1, Fig. 1). Water samples were collected from the middle stream of the rivers and approx. 0.5 meter below the water surface in triplicate.

2.2. Sample collection and analysis

A total of 15 water quality parameters were analyzed. Temperature, pH, DO, TDS, and EC were analyzed *in situ* with the help of portable water analysis kit (GPS Aqua Meter-AP-1000, Aqua Read Ltd, U.K.) and calibration was done at each site before measurement with the help of Rapid Calibration Solution. For the measurement of other parameters, water samples were collected in polyethylene bottles rinsed with 15% HNO_3 (v/v). Collected samples were stored in refrigerator at 4 °C for subsequent analysis. Measurement of major cations and anions were carried out by Ion Exchange Chromatography (Dionex Corporation, Sunnyvale, CA, USA). Alkalinity of water was measured by auto-titrator (Micro-ohm).

Table 1
GPS locations of each sampling site.

Locations	Latitude	Longitude	Altitude	Description of site
Ram chaura ghat	N25°4.8647′	E081°38.7821′	102	A Ghat before entrance of river Ganges in city Allahabad
Neeva	N25°28.1309′	E081°47.0234′	77	River Ganges just entered in the Allahabad city and divides in 2 streams
Rasoolabad	N25°30.1482′	E081°51.3175′	71	A famous place for funeral activities at river bank
Daraganj	N25°26.7282′	E081°53.3840′	62	Another funeral place at river bank before Sangam
Prior to sangam	N25°25.5564′	E081°52.9738′	58	Ganges prior to confluence, Sangam
Sangam	N25°25.5836′	E081°52.9347′	70	Confluence point of river Ganges and Yamuna
Boat Club	N25°25.6967′	E081°51.3482′	63	Yamuna about 1 Km upstream from Sangam
Beyond sangam	N25°25.4731′	E081°52.9355′	53	River Ganges after confluence