



Water quality assessment of an unusual ritual well in Bangladesh and impact of mass bathing on this quality



H. Zabed^{a,b}, A. Suely^c, G. Faruq^{b,*}, J.N. Sahu^d

^a Department of Microbiology, University of Chittagong, Chittagong 4331, Bangladesh

^b Institute of Biological Sciences, Faculty of Science, University of Malaya, Kuala Lumpur 50603, Malaysia

^c Department of Zoology, University of Chittagong, Chittagong 4331, Bangladesh

^d Department of Petroleum and Chemical Engineering, Faculty of Engineering, Institut Teknologi Brunei, Tungku Gadong, P.O. Box 2909, Brunei Darussalam

HIGHLIGHTS

- Ritual well water was analyzed in three seasons and during mass bathing.
- Water fulfilled the standards for bathing water in all seasons.
- Physicochemical parameters fluctuated unusually during mass bathing.
- Microbial indicator concentration increased after the mass bathing.
- Some parameters and indicators showed significant relationship among them.

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ABSTRACT

A sacred ritual well with continuously discharging of methane gas through its water body was studied for physicochemical and microbiological quality in three seasons and during ritual mass bathing. Most of the physicochemical parameters showed significant seasonal variations ($P < 0.05$) and a sharp fluctuation during mass bathing. Dissolved oxygen (DO) was found negatively correlated with temperature ($r = -0.384$, $P < 0.05$), biochemical oxygen demand (BOD) ($r = -0.58$, $P < 0.001$) and ammonia ($r = -0.738$, $P < 0.001$), while BOD showed positive correlation with chemical oxygen demand (COD) ($r = 0.762$, $P < 0.001$) and ammonia ($r = 0.83$, $P < 0.001$). Simple regression analysis also yielded significant linear relationship in DO vs. temperature ($r^2 = 0.147$, $P < 0.05$), DO vs. ammonia ($r^2 = 0.544$, $P < 0.001$) and BOD vs. DO ($r^2 = 0.336$, $P < 0.001$). A total of eight microbial indicators were studied and found that all of them increased unusually during mass bathing comparing with their respective seasonal values. Total coliforms (TC) were found positively correlated with fecal coliforms (FC) ($r = 0.971$), FC with *Escherichia coli* (EC) ($r = 0.952$), EC with intestinal enterococci (IE) ($r = 0.921$), fecal streptococci (FS) with IE ($r = 0.953$) and *Staphylococcus aureus* (SA) with *Pseudomonas aeruginosa* (PA) ($r = 0.946$), which were significant at $P < 0.001$. Some regression models showed significant linear relationship at $P < 0.001$ with r^2 value of 0.943 for FC vs. TC, 0.907 for EC vs. FC, 0.869 for FS vs. FC, 0.848 for IE vs. EC and 0.909 for IE vs. FS. The overall results found in this study revealed that well water is suitable for bathing purpose but the religious activity considerably worsens its quality.

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1. Introduction

The Chandra Nath Hill, located at Sitakunda Upazila (sub-district) under Chittagong district in Bangladesh, is one of the holiest places in the country to the Hindu community since very past for the presence

Abbreviations: BOD, biochemical oxygen demand; CFU, colony forming unit; COD, chemical oxygen demand; DO, dissolved oxygen; EC, *Escherichia coli*; FC, fecal coliforms; FS, fecal streptococci; IE, intestinal enterococci; MPN, most probable number; PA, *Pseudomonas aeruginosa*; SA, *Staphylococcus aureus*; TC, total coliforms; TVBC, total viable bacterial count.

* Corresponding author. Tel.: +60 3 79675805; fax: +60 379675908.

E-mail address: faruq@um.edu.my (G. Faruq).

of ancient temples on the hill top and several ritual activities. In Barabkunda (a place under Sitakunda) section of this hill (Longitude 22.582612 N and Latitude 91.701748 E), there is another holly place where four old and almost broken temples are located adjacently (Fig. 1), which were mysteriously built on the unapproachable hill top in an unknown period of time though the current priest of the temple demands that these were made about 350 years ago. In the underground of the middle temple, a rectangular natural well (Length, breadth and depth are approximately 3.5, 1.5 and 2.5 m respectively) is located where ground water along with methane gas is continuously discharging to the surface of its water body. But the flow of water is not strong enough resulting in a very slow streaming toward the back side

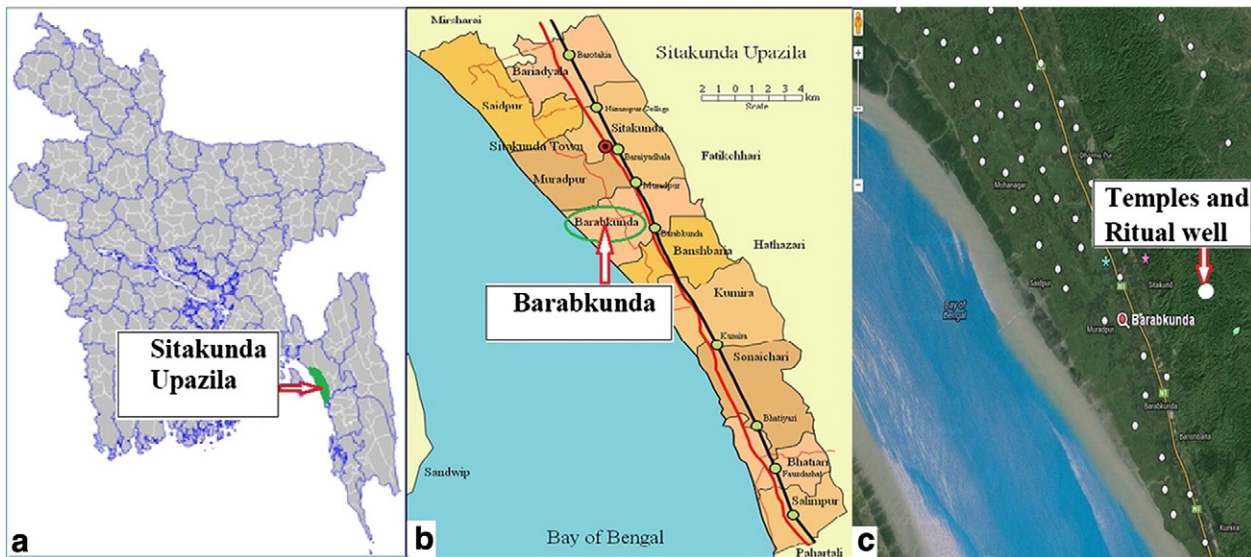


Fig. 1. (a) Upazila (sub-district) map of Bangladesh indicating (green area) the location of Sitakunda Upazila (source: http://en.wikipedia.org/wiki/Upazilas_of_Bangladesh). (b) Sitakunda Upazila map indicating (green circle) Barabkunda (source: http://commons.wikimedia.org/wiki/File:Sitakunda_Upazila_Map.svg) and (c) approximate location of the temples and studied well at Barabkunda on the hill (source: <http://mapcarta.com/15271034>).

hill. In one side of the well, methane gas is so strongly discharging that there is a continuous fire burning over the water all round the year as long as anybody wishes to switch it off (Fig. 2). This made the place sacred to the Hindus, eventually pilgrims and devotees from across the country visit here for their ritual activities. The place is located approximately 4–5 km away from the Dhaka–Chittagong Highway at Barabkunda town and walking through the hills and forest is the only way to get to it. For this reason only once in every year (10 Falgun i.e., 23 February) they get together here to worship the fire and to have a ritual bath in the well that washes out their sins as they believe. They call this mass bathing event “Tirtho Snan” (Dedicated Bathing). Approximately 5–10 thousand or more people gather here on this occasion and a good number (about two-third) of them take a bath or make their body wet with the well water.

Bathing or recreational water quality evaluation is to some extent relying on the physicochemical parameters of the water. Several parameters such as temperature, pH, DO, BOD, COD, total alkalinity, chloride, ammonia etc. have been studied in different surface water systems used for bathing purposes by different researchers to determine the water quality that concluded with some deviation in these parameters for some anthropogenic or natural reasons (Arvanitidou et al., 2005;

Bhatnagar and Devi, 2012; Debels et al., 2005; Kumar et al., 2012; Ouyang et al., 2006).

Microorganisms are commonly used as indicators of bathing or drinking water quality assessment for their wide distribution, abundance and diversification in nature (Baghel et al., 2005; Okpokwasili and Akujobi, 1996). The widely used indicators include mainly fecal contaminants such as TC and FC (Noble et al., 2003; Sood et al., 2008) or more specifically EC (Mansilha et al., 2009). In addition, FS and IE are considered the better indicators as they can stay alive in water longer time than FC or EC (Gleeson and Gray, 2002; Zhang et al., 2013). Presence of these fecal contaminants in bathing water poses the risk for various water borne diseases (Moresco et al., 2012). Considering this health risk, several regulatory organizations, countries and regions prescribed fecal indicators as the standards for bathing water assessment though there is the lacking of universal agreement to use the most appropriate polluting indicators (EEC, 1976, 2006; USEPA, 1986). However, evaluation of fecal contaminants does not necessarily assess the risk of non enteric pathogens such as SA and PA which have alarmingly been detected from different surface and recreational water systems (Casanovas-Massana and Blanch, 2013; Plano et al., 2011; Suzuki et al., 2013; Tirodimos et al., 2010). PA from such contaminated water



Fig. 2. (a) Stairs of the middle temple to go to the well and (b) ritual well showing continuous fire burning over water due to the discharging of the methane gas; lighting is artificial as the well is located in underground and no sunlight can reach there (Courtesy by Fawaz Rob).

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