Evaluating Water Quality of Ganga River Within Uttar Pradesh State by Water Quality Index Analysis Using C++ Program

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Abstract

The Ganga basin accounts for a little more than one-fourth (26.3%) of the country's total geographical area and is the biggest river basin in India, covering the entire states of Uttarakhand (UK), Uttar Pradesh (UP), Bihar, Delhi, and parts of Punjab, Haryana, Himachal Pradesh, Rajasthan, Madhya Pradesh, and West Bengal. In this study we chose Uttar Pradesh (UP) as maximum area in water pollution on Ganga River. For purpose of this study we have 13 monitoring station along with Ganga River in UP state. The present study shows evaluation of water quality for Ganga River within UP using WQI analysis by C++ program. In the case of Ganga River the concentrations of BOD, TH, PO_4, NO_3, EC and PH were found to be outside the acceptable range of WHO standards.

Keywords: Ganga River; Water Quality; WQI; C++ Program and River Evaluation

1. Introduction

India's water future is in danger if current trends in its use continue. The total annual surface water availability in the country is estimated to be 1,869 billion cubic meter (bcm). Due to spatial-temporal variations, an estimated 690 bcm of surface water is utilizable. Add to this 432 bcm of replenish able groundwater, and the total utilizable water in the country is 1,122 bcm, which appears to be just about sufficient to meet our present needs. Since the total available water is more or less constant, rising demands due to population and economic growth will strain the demand-supply balance. The Water Resources Group estimates that if the current pattern of demand continues, about half of the demand for water will be unmet by 2030 (WRG, 2009).

Even the present situation is tenuous. Although at the macro level, demand and supply of water seem to balance, there are stark differences at the basin levels. Of the 20 major river basins in India, 14 are already water-stressed Nearly three-fourth of India's population lives in water-stressed regions (where per capita availability is less than 2,000 cubic meters per year) of which one-third of the region is in water, scarce areas (where per capita water availability is less than 1,000 cubic meters per year). Climate change will further aggravate the problem by causing erratic weather patterns. More extreme rates of precipitation and evapo-transpiration will cause more instances of droughts and floods, with disparate and complex effects at the sub-basin level (IIR, 2011).

The river Ganga occupies a unique position in the cultural ethos of India. Legend says that the river has descended from Heaven on earth as a result of the long and arduous prayers of King Bhagirathi for the salvation of his deceased ancestors. From times immemorial, the Ganga has been India's river of faith, devotion and worship. Millions of Hindus accept its water as sacred. Even today, people carry treasured Ganga water all over India and abroad because it is "holy" water and known for its "curative" properties.

However, the river is not just a legend, it is also a life-support system for the people of India (WHO/UNEP, 1997). It is important because:

- The densely populated Ganga basin is inhabited by 37 per cent of India's population.
- The entire Ganga basin system effectively drains eight states of India.
- About 47 per cent of the total irrigated area in India is located in the Ganga basin alone.
- It has been a major source of navigation and communication since ancient times.
- The Indo-Gangetic plain has witnessed the blossoming of India's great creative talent.

Water pollution is a major problem that is threatening the sustainability of water bodies. Punitive mechanisms, such

as closure of industries for non-compliance, alone have not worked. Market-based mechanisms comprising taxes on polluting industries, and tax concessions for adoption of abatement technologies, should supplement the current legislation. Mechanisms such as green ratings should also be promoted and eventually be made mandatory (IIR, 2011).

2. Objectives and Approach

The objective envisaged for this study is critical evaluation of present status of water environment and services in Ganga River, India. For this purpose, the relevant information has been collected and analyzed as below:

1. Evaluation of Ganga River water quality.
2. Refine or create Ganga River specific water quality standards pursuant to International standards including development of appropriate reference conditions.
3. To provide an early warning system for downstream users about adverse water quality conditions.

3. Materials and Methods

3.1 Study Area

The Ganga River has significant economic, environmental and cultural value in India. Rising in the Himalayas and flowing in to the Bay of Bengal, the river traverses a course of more than 2,500 km through the plains of north and eastern India. The Ganga basin – which also extends into parts of Nepal, China and Bangladesh – accounts for 26 per cent of India's landmass, 30 per cent of its water resources and more than 40 per cent of its population. The Ganga also serves as one of India's holiest rivers whose cultural and spiritual significance transcends the boundaries of the basin (NGRBA, 2011).

Ganga is a perennial river which originates as a stream called "Bhagirathi" from Gaumukh in the Gangotri glacier at 30 ° 55' N, 79 ° 7' E, some 4100 m above mean sea level. Ganga river basin is the largest among river basins in India and the fourth largest in the world, with a basin (catchment area) covering 8, 61,404 sq km. It has a total length of 2,525 km, out of which 1,425 km is in Uttaranchal and UP, 475 km is in Bihar and 625 km is in West Bengal. Already half a billion people live within the river basin, at an average density of over 500 per sq km, and this population is projected to increase to over one billion people by the year 2030 (Rakesh, 2007).

The Ganga basin is one of the most populous regions on Earth, home to 450 million people at an average density of over 550 individuals per square kilometre. In the delta zone this rises to over 900 per square kilometre. As a result, there is strong demand and competition for natural resources, especially water for domestic use and irrigation, and barrages regulate most of the basin tributaries. Fisheries along the river are of considerable economic value and their output makes a major contribution to regional nutritional needs (WWF, 2010).

There are some 30 cities, 70 towns, and thousands of villages along the banks of the Ganga. Nearly all of the sewage from these population centres – over 1.3 billion litres per day – passes directly into the river, along with thousands of animal carcasses, mainly cattle. Another 260 million litres of industrial wastewater, also largely untreated, are discharged by hundreds of factories, while other major pollution inputs include runoff from the more than 6 million tonnes of chemical fertilizers and 9,000

tonnes of pesticides applied annually within the basin. According to Hindu mythology, the Ganga River came down to Earth from the heavens. Today, the river symbolizes purification to millions of Hindus who believe that drinking or bathing in its waters will lead to moksha, or salvation. Many Hindus keep water from the Ganga in glass bottles as a sacred relic, or for use in religious ceremonies. The river becomes the final resting place for thousands of Hindus, whose cremated ashes or partially burnt corpses are placed in the river for spiritual rebirth (WWF, 2010).

3.2 Critical stretches of the Ganga:

In different stretches the holy Ganga River is posed with different challenges (see fig.1) (CSE, 2008).

- In the upper reaches (Himalayan segment) numerous hydel projects (commissioned as well as planned) threaten the river ecosystem by depriving it off the environmental flows
- In the stretch beyond this (till Patna) the growing cities and industrial clusters have increased the pollution load discharged into the river. Loss of assimilative capacity has worsened the pollution woes of the river.

- In the stretch beyond Patna, the river is relatively clean. But growing cities and lack of assimilation is making the river dirtier.

Fig. 2 shows images for Ganga River pollution within India.

3.3 River Water Pollution

A river is defined as a large natural stream of water emptying into an ocean, lake, or other body of water and usually fed along its course by converging tributaries. Rivers and streams drain water that falls in upland areas. Moving water dilutes and decomposes pollutants more rapidly than standing water, but many rivers and streams are significantly polluted all around the world.

A primary reason for this is that all three major sources of pollution (industry, agriculture and domestic) are concentrated along the rivers. Industries and cities have historically been located along rivers because the rivers provide transportation and have traditionally been a convenient place to discharge waste. Agricultural activities have tended to be concentrated near rivers, because river floodplains are exceptionally fertile due to the many nutrients that are deposited in the soil when the river overflows.

3.3.1 Source of pollution

Farmers put fertilizers and pesticides on their crops so that they grow better. But these fertilizers and pesticides can be washed through the soil by rain, to end up in rivers. If large amounts of fertilizers or farm waste drain into a river the concentration of nitrate and phosphate in the water increases considerably.

Algae use these substances to grow and multiply rapidly turning the water green. This massive growth of algae, called eutrophication, leads to pollution. When the algae die they are broken down by the action of the bacteria which quickly multiply, using up all the oxygen in the water which leads to the death of many animals (CWC, 2011).

Chemical waste products from industrial processes are sometimes accidentally discharged into rivers. Examples of such pollutants include cyanide, zinc, lead, copper, cadmium and mercury. These substances may enter the water in such high concentrations that fish and other animals are killed immediately.

Sometimes the pollutants enter a food chain and accumulate until they reach toxic levels, eventually killing birds, fish and mammals.

Factories use water from rivers to power machinery or to cool down machinery. Dirty water containing chemicals is put back in the river. Water used for cooling is warmer than the river itself. Raising the temperature of the water lowers the level of dissolved oxygen and upsets the balance of life in the water. People are sometimes careless and throw rubbish directly into rivers.

3.3.2 River water quality & Environmental factors

River water quality is highly variable by nature due to environmental conditions such as basin lithology, vegetation and climate. In small watersheds spatial variations extend over orders of magnitude for most major elements and nutrients, while this variability is an order of magnitude lower for major basins. Standard river water for use as reference is therefore not applicable. As a consequence natural waters can possibly be unfit for various human uses, even including drinking.

There are three major natural sources of dissolved and soluble matter carried by rivers: the atmospheric inputs of material, the degradation of terrestrial organic matter and the weathering of surface rocks. These substances generally transit through soil and porous rocks and finally reach the rivers. On their way, they are affected by numerous processes such as recycling in terrestrial biota, recycling and storage in soils, exchange between dissolved and particulate matter, loss of volatile substances to the atmosphere, production and degradation of aquatic plants within rivers and lakes etc. As a result of these multiple sources and pathways, the concentrations of elements and compounds found in rivers depend on physical factors (climate, relief), chemical factors (solubility of minerals) and biological factors (uptake by vegetation, degradation by bacteria). The most important environmental factors controlling river chemistry are (CWC, 2011):

- Occurrence of highly soluble (halite, gypsum) or easily weathered (calcite, dolomite, pyrite, olivine)

minerals.

- Distance to the marine environment which controls the exponential decrease of ocean aerosols input to land (Na^+, CI^-, $SO4^{-2}$, and Mg^{+2}).
- Aridity (precipitation/runoff ratio) which determines the concentration of dissolved substances resulting from the two previous processes.
- Terrestrial primary productivity which governs the release of nutrients (C, N, Si, K).
- Ambient temperature which controls, together with biological soil activity, the weathering reaction kinetics.
- Uplift rates (tectonism, relief) Stream quality of unpolluted waters (basins without any direct pollution sources such as dwellings, roads, farming, mining etc.

3.4 Water Quality Index

3.4.1 Purpose:
Perform tests to determine the Water Quality Index (WQI) of a local body of water Perform follow-up WQI tests to establish an ongoing record and basis for possible water remediation (Molnar, 2010).

3.4.2 Background:
A water quality index provides a single number (like a grade) that expresses overall water quality at a certain location and time based on several water quality parameters. The objective of an index is to turn complex water quality data into information that is understandable and useable by the public. This type of index is similar to the index developed for air quality that shows if it's a red or blue air quality day. The use of an index to "grade" water quality is a controversial issue among water quality scientists. A single number cannot tell the whole story of water quality; there are many other water quality parameters that are not included in the index. The index presented here is not specifically aimed at human health or aquatic life regulations. However, a water index based on some very important parameters can provide a simple indicator of water quality. It gives the public a general idea the possible problems with the water in the region (Mitchell, 2000). **Table 1** showing Water Quality Index Ranges (Hameed, 201; Brown, 1970).

3.4.3 Water Quality Index Calculation
The WQI was calculated using the standards of drinking water quality recommended by the World Health Organization (WHO) (Aenab, 2012). The weighted arithmetic index method was used for the calculation of WQI of the surface water. Further, quality rating or sub index (qn) was calculated using the following expression (Brown, 1970).

$$qn = 100\,[Vn - Vio]/[Sn - Vn]$$

(Let there be n water quality parameters and quality rating or sub index (qn) corresponding to nth parameter is a number reflecting the relative value of this parameter in the polluted water with respect to its standard, maxi- mum permissible value).
qn = Quality rating for the nth water quality parameter
Vn = Estimated value of the nth parameter at a given sampling point.
Sn = Standard permissible value of the nth parameter.
Vio = Ideal value of nth parameter in pure water (*i.e.* 0 for all other parameters except the parameter pH and Dissolve Oxygen (7.0 and 14.6 mg/L respectively).
Unit weight was calculated by a value inversely pro- portional to the recommended standard
value Sn of the corresponding parameter.
Wn = K/Sn
Wn unit weight for the nth parameters.
Sn = standard value for the nth parameters
K = constant for proportionality.
The overall WQI was calculated by aggregating the quality rating with the unit weight linearly.

WQI = ∑ qnWn / ∑ Wn

3.4.4 Parameter Selection

There are so many different parameters that can be used to measure water quality. From a global perspective it is important to outline a few consistent measurements that can be measured easily, by all, on a regular basis, and that are clearly correlated to biodiversity in aquatic environments. The specific parameters used to assess water quality were chosen based on findings reported in the primary literature.

3.5 Application of C++ Program

3.5.1. Introduction

C++ is a statically typed, free-form, multi-paradigm, compiled, general-purpose programming language. C++ is sometimes called a hybrid language. It is regarded as an intermediate-level language, as it comprises a combi- nation of both high-level and low-level language features (Schildt, 1998). It was developed by Bjarne Stroustrup starting in 1979 at Bell Labs as an enhancement to the C language. Originally named C with Classes, the language was re-named C++ in 1983 (Stroustrup, 2010). C++ is one of the most popular programming languages [(PLP, 2010),(TPCI, 2011)] with application do- mains including systems software, application software, device drivers, embedded software, high-performance server and client applications, and entertainment software such as video games (C++, 2010). Several groups provide both free and proprietary C++ compiler software. C++ has greatly influenced many other popular programming lan- guages, most notably C# and Java. After years of deve- lopment, the C++ programming language standard was ratified in 1998 as ISO/IEC 14882:1998. The standard was amended by the 2003 technical corrigendum, ISO/ IEC 14882:2003. The current standard extending C++ with new features was ratified and published by ISO in September 2011 as ISO/IEC 14882:2011 (informally known as C++11) [(ISO, 2011), (MPPL, 2011)].

3.5.2. Algorithms and Steps

In my work using language C++ under window to execution, and perform some steps to implementation this program (Aenab, 2012):

- Create Project File consist of number of files.
- Create dialog boxes that perform to dialog with users.
- Read and input Data to system for all stations from users.
- Select type of process from menu (Water Quality Index).
- Execution algorithm and calculate mathematics for all process after enter data.
- Display Result with high speed (Less than 1 second). As is shown in table 2.

4. Results

The status of water quality of Ganga River in Uttar Pradesh is presented in Table 2. It is observed from the table that, the parameters values it was BOD (6.5 mg/l), TH (421 mg/l), NO_3 (11.7 mg/l), PO_4 (0.068 mg/l), EC (1200 mg/l) and PH (9) all parameters values out of the WHO standard values.

5. Conclusions

Water Quality Index (WQI) in total 137.7924 for the year 2011 and this make it under category more than 100, so it means water quality of Ganga River in Uttra Pradesh unsuitable.

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Table (1) Water Quality Index Categories

WQI	0-25	26-50	51-75	76-100	>100
Water Quality	Excellent	Good	Poor	Very poor	Unsuitable

Source: Brown et al., 1970

Table 2. Water Quality Index result for Ganga River within UP by C++ Program for the year 2011

Water Quality Index (WQI) Scale

Parameters	Observed value	V standard	Unit Weight	Quality rating	WnQn
BOD	6.5	5	0.200000	130.000000	26.000000
T.H	421	30	0.033333	1403.333374	46.777782
Mg	60.5	200	0.005000	30.250000	0.151250
Ca	100	200	0.005000	50.000000	0.250000
T.D.S	450	500	0.002000	90.000000	0.180000
CL	110	250	0.004000	44.000000	0.176000
SO4	161	200	0.005000	80.500000	0.402500
NO3	11.7	10.0	0.100000	117.000000	11.700000
PO4	0.068	0.05	20.000000	136.000000	2720.000000
EC	1200	1000	0.001000	120.000000	0.120000
PH	9	8.5	0.117647	133.333328	15.686274
Na	80	250	0.004000	32.000000	0.128000
Sum	2609.7681	2653.5500	20.4770	2366.4167	2821.5718

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Water Quality Index (WQI)	137.7924
Type of (WQI)	Unsuit-Able

Fig. 1 Ganga River in India (Source: Centre for Science and Environment, New Delhi, October 2008)

Fig. 2 Images for Ganga River pollution

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