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GIS Based Study of Physico-Chemical Properties of River Ganges Water during Post Monsoon Season for Varanasi City, UP, India

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Abstract

The Ganga river basin facing huge anthropogenic activities and became a most favored site for disposal of municipal, industrial and agricultural waste. In last few decades it has increased the pollution load and hence degraded the water quality to great extent. To assess the water quality fluctuations, a water quality of river Ganga for Varanasi city is conducted during post monsoon season from upstream to downstream. The pollution load on the river was measured at five sampling sites i.e. Ramna as upstream, Samne Ghat, Assi Ghat, Dashashwamedh Ghat as a midstream and Raj Ghat as downstream to evaluate the physico- chemical properties in terms of pH, conductivity, suspended solid, TDS, DO and BOD. The result indicated that Ganga water quality at Varanasi has deteriorated to a large extent because of huge amount of sewage discharge. Lack of sewage treatment plant adds the pollution load. Geographical Information System (GIS), one of the powerful tools to represent and analyze the problem spatially was used in this study to indicate the pollution load at the in Ganga River. GIS can also suggest the optimal site selection for the sewage treatment plant (STP) on the basis of sewage load, quality and geographical conditions.

Keywords: River Ganga, DO, BOD, TDS, MLD, STP, GIS.

Introduction

River Ganges emanates from the Gomukh of Gangotri glacier at an elevation of 4120 m and flows through 250 km in the mountains then descends to an elevation of 288 m above the mean sea level[1]. At Dev Prayag, the river acquires the name Ganga by joining the Alakhnanda and Bhagirathi. It traverses a course of 2500 km through the province of Uttar Pradesh, Bihar, West Bengal before flowing into Bay of Bengal[2]. River Ganges is the longest river of India and is the second greatest river in the world by discharge. The plain of the Ganges is one of the most densely populated regions of the world due to its availability of water, fertile soil and suitable landscape with having more than 450 million people and a population density of about 1000 inhabitants per square miles. River Ganges covers 26 per cent of the country's landmass which supports 43 per cent of its population. The River Ganges was ranked among the five most polluted rivers of the world in 2007[3,4]. The Ganga basin is part of the composite Ganga-Brahmputra-Meghna basin which lies in China, Nepal, India and Bangladesh and drains an area of 1086,000 sq. km. Out of this basin area, 861,000 km^2, roughly 80%, is located in India[5]. The 14 out of 20 major river basins in India are already water stressed. Nearly three-fourth of India's population live in water stressed regions where per capita water availability is less than 2000 m^3 per year of which one third of the region is in water scarce areas where per capita availability of water is less than 1,000 m^3 per year.

India is water stressed and is likely to be water scarce by 2050 due to the continuous and increasing demand of water[6]. The River Ganges has shaped the cultural spiritual and economic life of people and supposed to be exposed to threat of serious ecological disasterlike Gangetic dolphins, which has become endangered animal that specifically habitat this river[7,8]. River Ganges is considered as lifeline for more millions of people but its ecosystem had experienced a drastic degradation since anthropocene[9]. Domestic and industrial wastewater constitutes a constant polluting source, whereas surface runoff is a seasonal phenomenon, mainly controlled by climate within basin. Along the banks of the River Ganges, over 29 cities, 70 towns and thousands of villages are situated. Nearly all of their sewage, over 1.3 billion liters per day goes directly to the river along with the thousands of animal carcasses, mainly cattle. Another 260 million liters of industrial waste are added to this by hundreds of factories along the river banks. Municipal Sewage constitutes 80% by volume of the total waste dumped into the River Ganges and industry contributes about 15%[10]. The industrial pollutant also contaminates the River Ganges to a great extent. The major polluting industries are the leather industries, especially near Kanpur, which contains large amount of chromium and other toxic chemicals and much of it finds its way into the meager flow of the River Ganges and responsible for about its 20% of the total water pollution[11].

At present, the water quality of River Ganges is in limelight which has deteriorated to a large extent because of huge amount

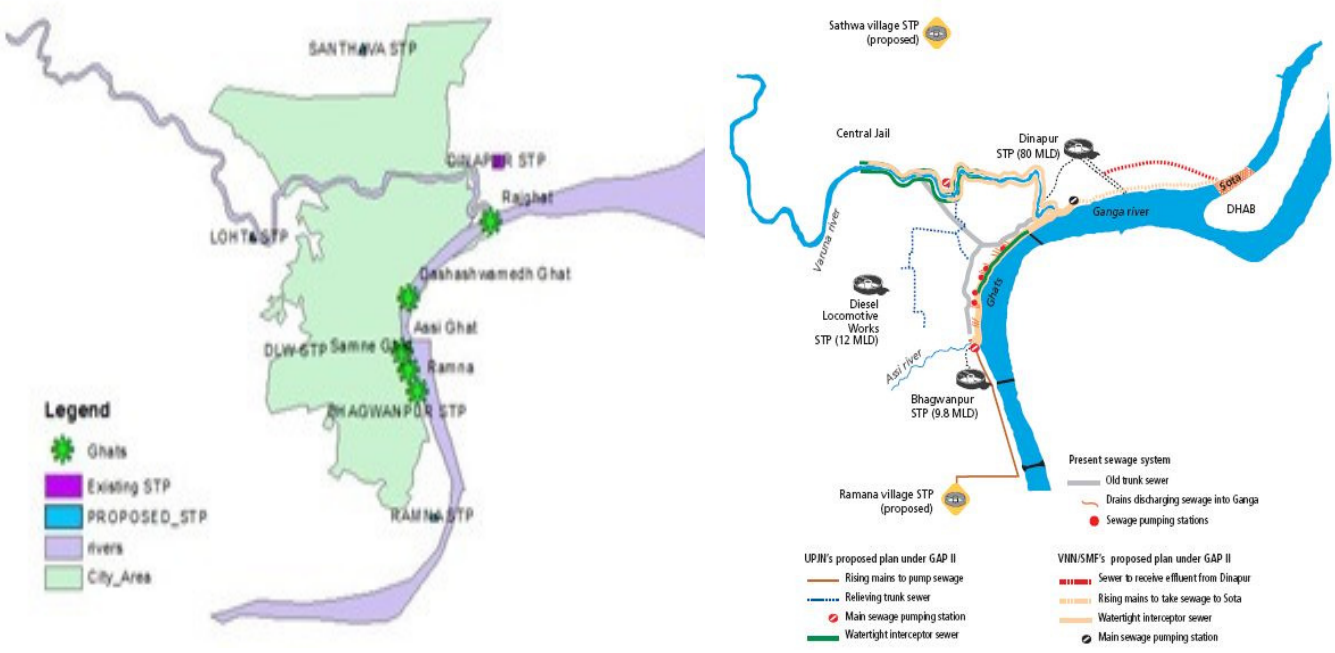
of sewage discharge into it (310 million liters per day). There are only 3 treatment plants in Varanasi, namely Dinapur STP (80 MLD), DLW STP (12 MLD) and Bhagwanpur STP (9.8 MLD). Everyday about 210 MLD raw sewage is directly discharged into the River Ganges. The ash and half burned bodies from cremation, effluents from various industries, mass bathing, marigold flower etc were the other sources of pollution. These pollutants from various sources have deteriorated the water quality by decreasing DO, pH and increasing conductivity, BOD, suspended solid and TDS[12]. The BOD level has increased to such a level that even it is not fit for bathing purpose also. The result of these effects can be seen on Gangeticdolphins which have now become endangered. The efforts of the government to clean up the River Ganges by launching Ganga Action Plan[13] and National Ganga River Basin Authority[14] have not proved to be beneficial. The objectives of intercepting the sewage and treating it before discharge into the river in the past 30-odd years have remained the same. Currently, the development of the STPs at various places in Varanasi is in urgent need to make River Ganges free from heavy sewage pollution load.

GIS is an integrated system for storing, manipulating, analyzing and visualizing geographically referenced data. Inverse distance weighted (IDW) interpolation is a method to show the effect of various parameters on the study area. IDW is a tool available in ArcGIS 10.2.2 software which is useful in determining cell values using linearly weighted combination of a set of sample points. The weight is a function of inverse distance. GIS can also help in spatial planning support system to find the optimal site selection of STPs. This paper thus helps to understand various pollution problems which can be useful in improving the water quality of River Ganges spatially with GIS based map.

Material and Method

Sample collection and preservation: Water samples were collected in carefully rinsed plastic container at each 15 days/interval for a period of 3 months i.e. 6 January 2012- 21 March 2015 between 8.00 AM to 10.00 AM from five sampling sites i.e. Ramna (as upstream) Samne Ghat, Assi Ghat, Dashashwamedh Ghat (as midstream) and Raj Ghat (as downstream) and were brought to the laboratory for analysis.

Analysis: The water samples were analyzed by using standard methods for the examination of water and waste water[15]. The temperature, pH and conductivity were recorded at the sites with the help of mercury thermometer, pH meter and conductivity meter respectively. The DO of the water sample were fixed with the help of 2ml mangnoussulphate and 2ml alkali-iodide-azide solution at the sites and analyzed in the laboratory using Winkler's modified iodide-azide method and BOD by incubating sample at 25^0C for 5 days in incubator.



(a) (b)

Figure-1

(a) Five sample locations (Ramna, Samne Ghat, Assi Ghat, Dashashwamedh Ghat and Rajghat) marked as green and 3 working STPs (Dinapur STP, Bhagwanpur STP, and DLW STP) and 3 sanctioned STPs (Ramna STP Lohta STP and Santhwa STP) marked as violet (b) Current sewage management condition of Varanasi city[4]

Sources of pollution: The sources were following

Ramna Ghat Site I (25.2601^0, 83.0222^0): Ramna was taken as upstream from where the River Ganga enters to main city. It was least affected by anthropogenic activities and almost free from domestic and sewage discharge except agricultural runoff.

Samne Ghat Site II (25.2836^0, 83.0094^0): It was situated downstream to the Ramna. Here Domestic Discharge and construction of bridge was the main sources of pollution.

Assi Ghat Site III (25.2893^0, 83.0067^0): The sources of pollution at this Ghat were huge waste water through Assi River containing oil, grease, sewage, flowers and dhoop.

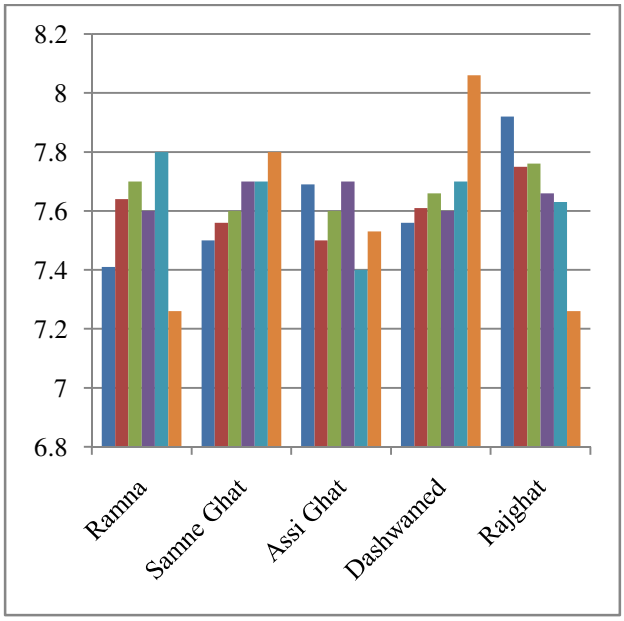
Dashashwamedh Ghat Site IV (25.3067^0, 83.01069^0): Here mass bathing, sewage, huge amount of marigold flowers with pesticides and dhoop as well as boating were main source of pollution. Sewage pumping house at this Ghat is also contributing the pollution and disturbing the aquatic flora and fauna.

Raj Ghat Site V (25.3266^0, 83.0389^0): It was situated taken as downstream, the largest and huge amount of raw sewage disposal site.

Results and Discussion

pH: The pH of the Dashaswamedh Ghat was highest than other sites. Here, the pH ranged from 7.56 on January 6 to 8.06 on March 21 which was more alkaline (Figure-2a). The reason of this increased pH was using soaps and detergents at Ghats during mass bathing and washing clothes. Dhobhi Ghat was also one of the causes of increased pH which flow towards this Ghat which made the water harder than the other sites. Raj Ghat was identified as having minimum pH i.e. 7.26 on 21st March because it was the site of greatest sewage discharge among all the sites so the increased microbial activity to decompose the organic materials by utilizing DO, released CO_2, which decreased the pH from 7.92 to 7.26 from winter to spring. The Results indicated that the water was slightly alkaline and within the permissible limit of Indian Water Standard (2009) due to strong buffering capacity of the river water. Figure-2b suggested that the average value of the pH of different site was almost same.

Conductivity: The Conductivity of Assi Ghat was maximum i.e. 0.60 on March 21 due to discharge of huge amount of wastewater containing oil and other organic materials containing charged ions, suspended and dissolved solids directly into the River Ganges through Assi River (Figure-3a). The conductivity of the Dashashwamedh Ghat was also found to be increased from 0.38 to 0.59 on January 6 to March 6 respectively because this Ghat was amongst the maximum anthropogenically disturbed Ghat. Here the most important cause of increased conductivity was boating, bathing and washing clothes and cattle. The results shown in GIS map indicated that conductivity varied spatially from upstream to downstream (Figure-3b).



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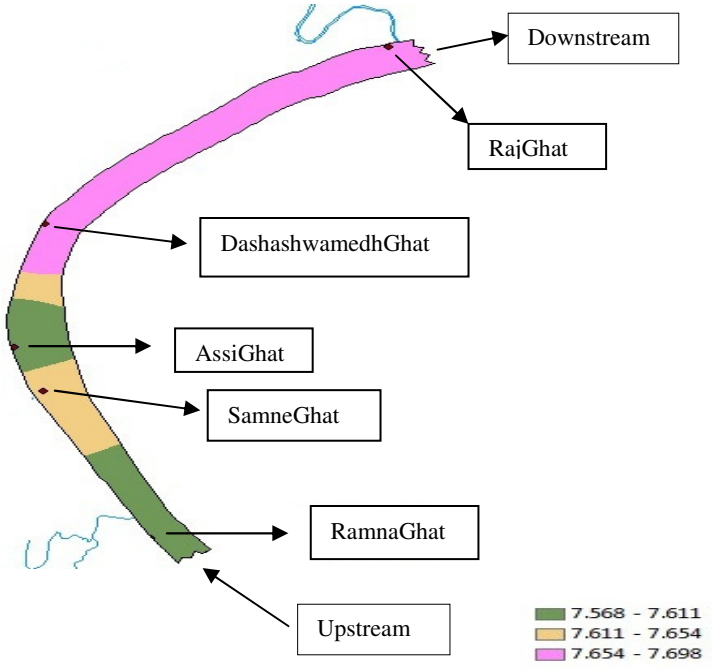
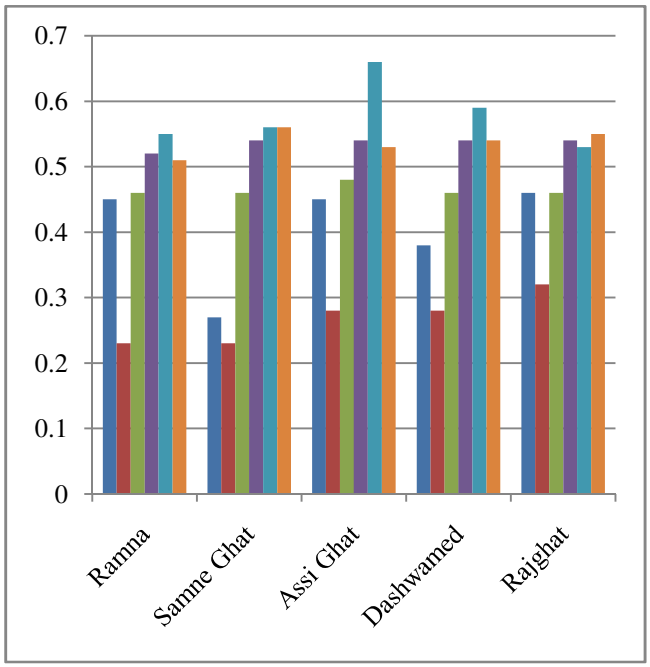


(b)

Figure-2
(a) pH of collected water samples at study site (b) GIS map showing the spatial distribution of pH at different sites

Suspended Solid: Suspended solid of the Assi Ghat was maximum i.e. 4.9 mg/l and of Ramna was minimum i.e. 1.2 mg/l because at Assi Ghat the discharged wastewater by Assi River was colloidal in nature containing oil, grease and huge amount of organic materials which directly released into the River Ganges. Ramna was completely free from any anthropogenic activity. Therefore, the suspended solids were minimum at Ramna Ghat and maximum at Assi Ghat (Figure-4a). Figure-4b, also corroborated that the value of suspended solid was maximum at Assi Ghat whereas minimum at Ramna.



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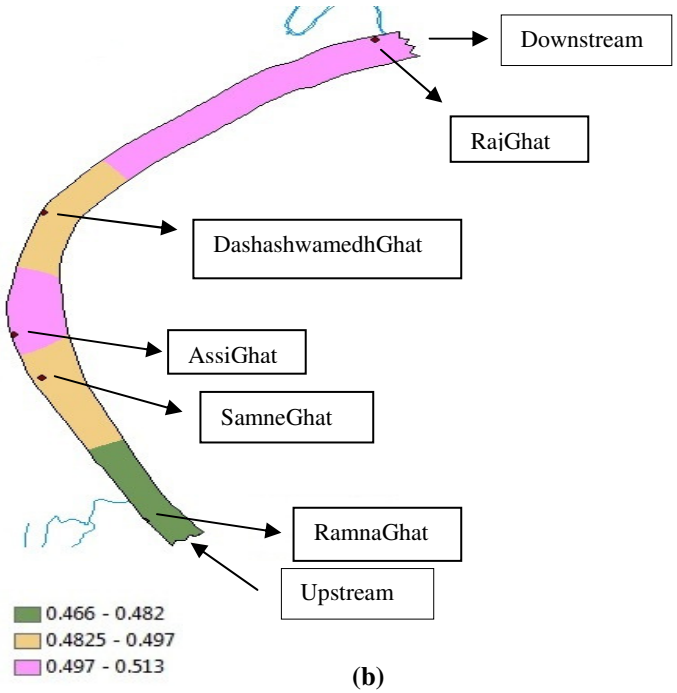
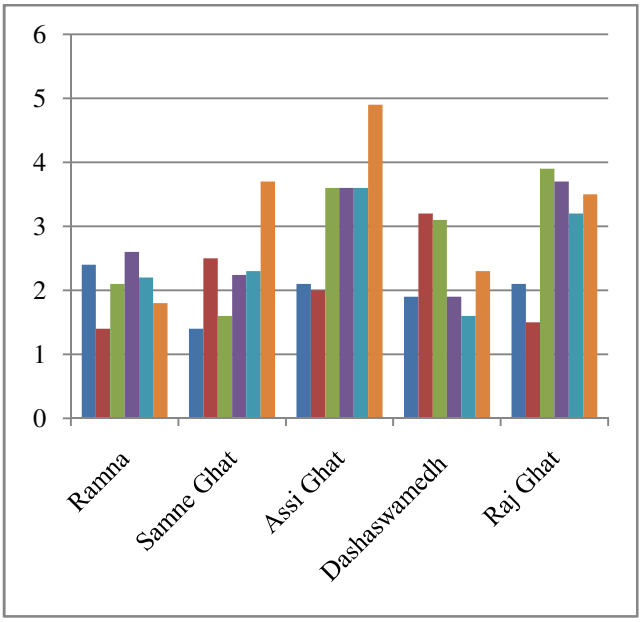


(b)

Figure-3

(a) Conductivity of collected water samples at study site (b) GIS map showing the spatial distribution of conductivity at different sites



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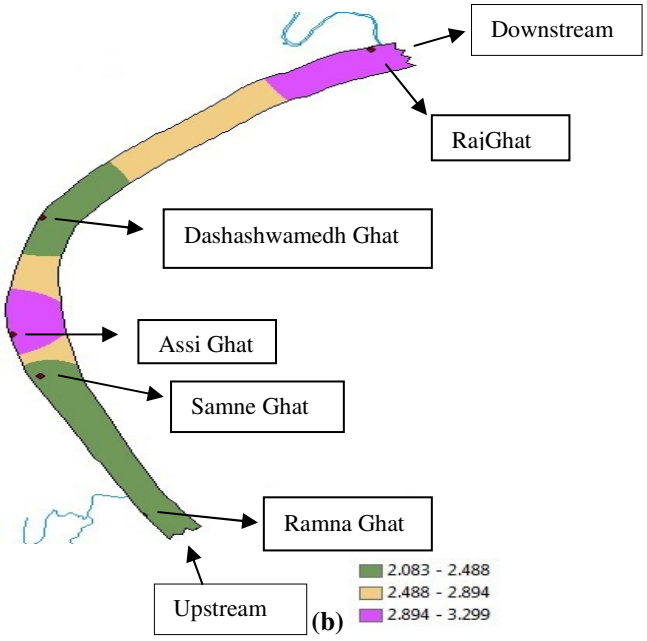


(b)

Figure-4

(a) Suspended solid of collected water samples at study site (b) GIS map showing the spatial distribution of SS at different sites

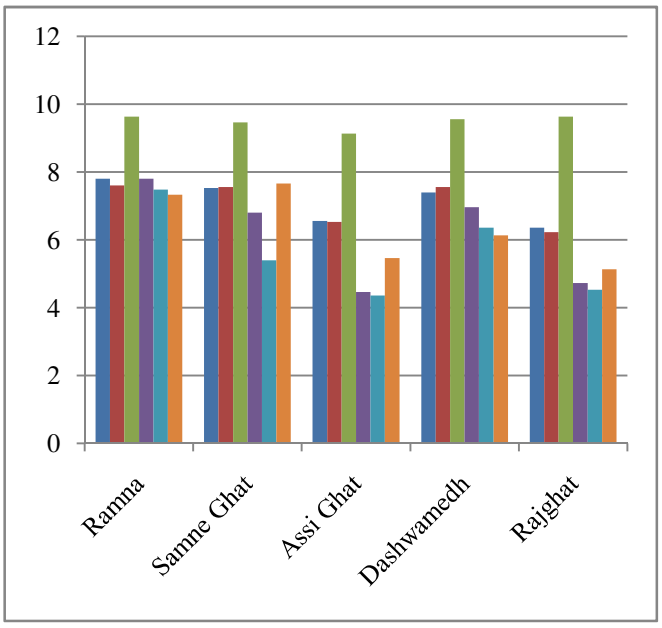
Dissolved Oxygen: The DO at Ramna site was highest because it was free from municipal, domestic and industrial wastewater discharge. Maximum DO at Ramna (upstream) was 10.63 mg/l on 6 Feb that spring season with continuous wind flow, which added oxygen by absorption in the river. It was also high because of photosynthesis of periphyton. The minimum DO at Assi Ghat (midstream) was 4.36 mg/l on March 6 due to direct discharge of raw sewage, domestic, industrial, medical, oil and grease into the river, decomposition by micro-organism further reduces dissolved oxygen (Figure 5a).The decreased dissolved oxygen has much affected the aquatic life of the river Ganga and the consequences of these can be seen on Ganges River Dolphin, *Platanistagangetica* and various fishes. Figure 5b shows that the value of DO at Ramna (upstream) was maximum whereas it was minimum at Assi Ghat (midstream).

Bio-chemical Oxygen Demand: BOD of site Ramna was lowest amongst all sites at each sampling. The minimum BOD was 13mg/l on Jan 6 and maximum was 21 mg/l on Mar 21. Higher BOD at Ramna was due to excessive decomposition of organic material like nitrate and phosphate using DO of the water. Highest BOD at Raj Ghat was 53 mg/l on Mar 6 and lowest was 25 mg/l on Jan 6 because it was highest raw sewage discharge site was badly affected by anthropogenic activity. The catchment area of Raj Ghat was affected with cattle dung and urine as well as their remaining fodder.

Total Dissolved Solid: The TDS at Assi Ghat was 401 mg/l highest on Feb 21 because this Ghat received a huge amount of inorganic and organic materials like nitrate, phosphate through Assi River which increased the dissolved solids. The Total dissolved solids were also added by daily anthropogenic activity like boating, fishing, bathing and washing. The GIS map (Figure-6) clearly shows average lowest TDS was recorded at Ramna in green color and average highest TDS at Raj Ghat with white color.

Conclusion

Day by day rapidly increasing pollution due to excessive sewage discharge, industrial and domestic effluents and solid waste dumping at Ramna, various anthropogenic activity like bathing, washing clothes, fishing, boating and spraying pesticides in marigold flower fields and other agricultural fields, huge cattle dung along Ghats especially as Assi and Raj Ghat into River Ganges beyond its carrying capacity has not only disturbed but changed the water quality of the river by decreasing the DO, pH and increasing conductivity, BOD, suspended solids and TDS. The BOD level has increased to such a level that even it is not fit for bathing purpose. The result of these effects can be seen on Gangetic Dolphin which has now become endangered species. There is an urgent need to implement several sewage treatment plants apart from the proposed. The Raw sewer is affecting river lethally and will continue increasing as the population increasing the load of sewage will be increasing.



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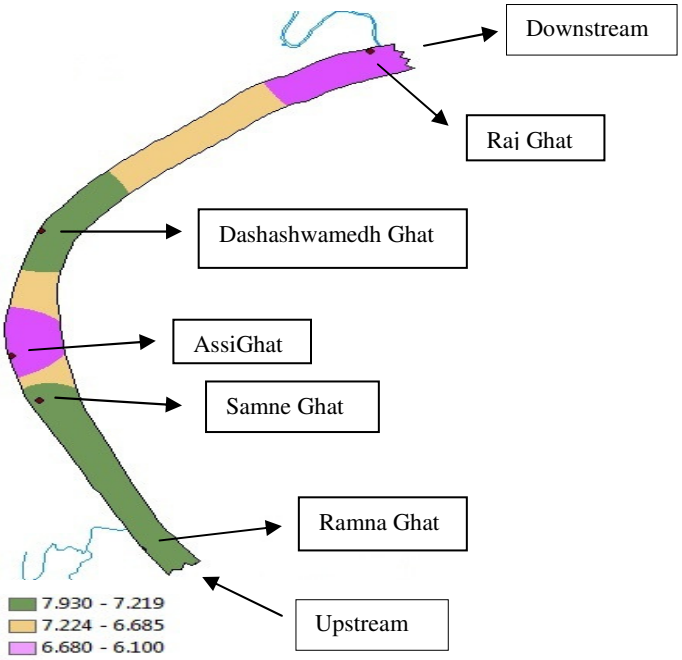

(b)

Figure 5
(a) Dissolved Oxygen of collected water samples at study site (b) GIS map showing the spatial distribution of DO at different sites

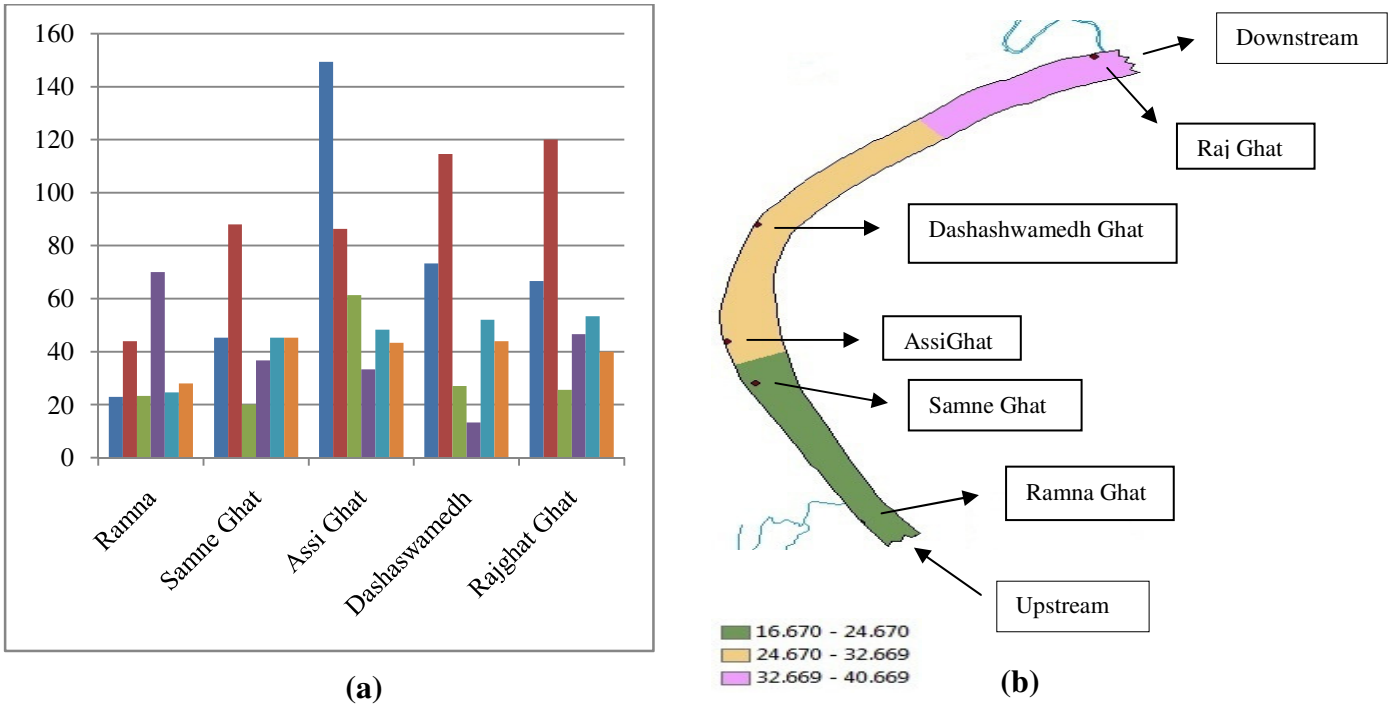

Figure-6
(a) Bio-chemical Oxygen Demand of collected water samples at study site (b) GIS map showing the gradual increase of BOD from upstream (Ramna) to downstream (Raj Ghat)

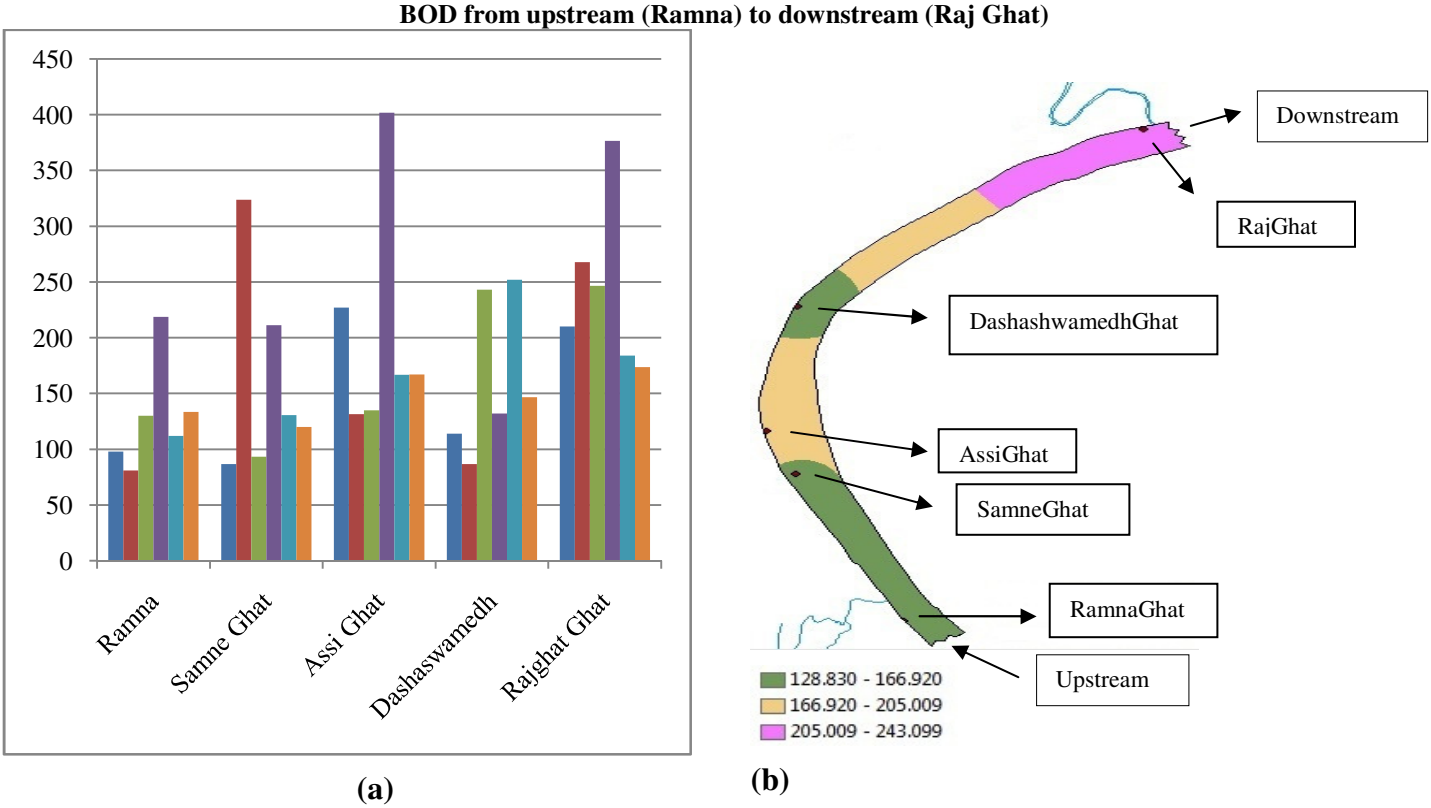

Figure-7
(a) TDS of the collected water samples at study site (b) GIS map showing of TDS from upstream (Ramna) to downstream (Raj Ghat)

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